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O. CHARNOCK BRADLEY, M.D., D.Sc., M.R.C.V.S.

VETERINARY HYGIENE

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Veterinary Hygiene

BY

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Professor of Hygiene, Royal (Dick) Veterinary College, Edinburgh

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To

Major-General Sir FREDERICK SMITH,

K.C.M.G., C.B.

PREFACE

This book has been written in the hope that it will be of assistance to veterinary students, veterinary practitioners, and others concerned with the well-being of animals. The requirements of those studying for the Diploma of Veterinary State Medicine have been kept in mind, and special attention has been given to certain branches of Public Health work with which they should be conversant. Other sections of veterinary science which might have been included, such as Dietetics, Zootechny and Milk Hygiene, have been omitted, as their importance merits a more detailed consideration than could be accorded in one volume. It is anticipated that they will later form additions to the Series.

I take this opportunity to express my gratitude to many friends for assistance in the preparation of the manuscript. Ventilation and Building Construction were written in collaboration with Mr. J. Alex. M'William, Licentiate R.I.B.A., P.A.S.I., whose wide practical knowledge and keen interest in the housing of live-stock have been of exceptional value; to him also I am indebted for illustrating these sections and feel sure that the care and labour he has bestowed on this important part of the book will be appreciated. The greater part of Preventive Medicine was written in conjunction with Capt. F. C. Minett, M.B.E., R.A.V.C.; Dr. G. A. Carse wrote the section on Meteorology; Professor G. H. Gemmell, F.I.C., criticised the sections dealing with Air and Water; Mr. G. W. Tully, M.R.San.I., read the manuscript on Sanitation and made many helpful suggestions; my colleagues, Professor J. Russell Greig and Mr. Wm. C. Miller, have been helpful in reading and correcting proof. The illustrations for the section on Sanitation were drawn by Mr. J. C. Dorsie, Kirkintilloch, and Mr. A. H. Baird, Edinburgh, kindly loaned those for Meteorology.

To the Publishers I am indebted in many ways, and particularly for the manner in which they have permitted free use of illustrations.

R. G. LINTON.

Edinburgh, February, 1921.

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CORRIGENDA.

Page 262.—In penultimate line for *actinomycis* read *actinomyces.*

Page 339.—Insert TREMATODES as a heading above paragraph on *Distomiasis.*

Page 346.—In first line for *Ostridæ* read *Oestridæ.*

Page 347.—In fourteenth line for *Ostrus* read *Oestrus.*

Page 361.—Read METHODS OF TRANSMISSION as a new heading referring to all varieties of parasitic mange.

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VETERINARY HYGIENE

SECTION I.

WATER.

WHEN rain falls upon the earth it may be evaporated to become once more atmospheric moisture; it may run on the surface until it reaches a stream, river or lake; or it may sink into the soil.

Rain Water as it descends from the clouds is pure and wholesome, but as soon as it comes in contact with the earth, or passes through the lower air strata over populous places it becomes altered in character. The modifications to which it is subjected from time to time vary greatly, and as it may be so changed as to become unwholesome or dangerous it is necessary for the hygienist to understand the causes and nature of the variation in quality in order that he may be in a position to adjudicate on the fitness or otherwise of a supply.

During its passage through the atmosphere rain absorbs oxygen, nitrogen and carbonic acid gas. Of these three it absorbs oxygen in greatest amount. Owing to its freedom from mineral matter it has an insipid taste and is not therefore so palatable as water that has percolated into the soil, but is specially suitable for washing purposes, as water containing much dissolved mineral is very destructive to soap. Since rain will absorb to itself any gases or particulate matter that may be in suspension in the air, it follows that the rain over country districts is much cleaner than that which falls over towns where the air is subjected to much pollution. Sodium chloride is to be found in the rain that falls over or near the sea. Snow water differs from rain water in that it has not had the same opportunity to absorb gases.

Surface Water. — This is rain water that has fallen on the earth, washed its surface, and has not yet penetrated sufficiently deep to rid itself of such impurities as it may have gathered. The character of such a water will vary with the nature of the ground on which it has fallen. In country districts not greatly polluted by animals or people, it will be comparatively free from contamination other than that of vegetable origin and such mineral

matter as it may dissolve. An excessive amount of vegetable matter may, however, be deleterious, and water lying on a peat soil often becomes acid. Some surface waters, though quite wholesome, may have a disagreeable colour, which is derived from the vegetable matter. Water derived from high-lying land is called Upland Surface Water and is usually pure. Surface water that has been in contact with human or animal excreta may be dangerous, and water from the surface of arable land should not be considered fit for drinking purposes until such time as it has been purified.

Brooks, Streams and Rivers are collections of water that has run on the earth's surface, together with water that has percolated to a certain depth and has again come to the surface as springs. The highest point of a river is its purest part, much of the water added to it as it increases in volume is contaminated surface water and is often waste water of an objectionable nature from factories, &c. It must not be thought that a clear-looking stream running through the country is necessarily pure and safe to drink, the reverse is often the case, as it is the common custom in villages for the inhabitants to discharge their soil water directly into the stream.

If a river was sufficiently long and was only polluted at or near its source it would purify itself of organic impurity by the aeration that takes place during its course. In this country, however, no rivers are capable of self purification, and as a rule the pollution increases as the river proceeds. River water contains a fairly high percentage of dissolved solids which it has gathered in its course; some of these may be later deposited and, as a river passes through beds of different geological formation, solids of varying nature may be gathered. It is well known that the character of the water in a river of any length may be quite different in the various sections. River water is in many instances used for the supply of towns, but owing to the contamination that takes place must be purified.

Lake Water.—Lakes, natural or artificial, are the common sources of supply for towns. A *Reservoir* is an artificial lake. The water forming a lake is that collected from an upland area; as a rule, therefore, it is pure, but as much of the land forming the catchment area is often of a peaty nature it may be acid, contain a considerable amount of organic matter and be discoloured. The basin of a lake is formed of rock on which the water has but little solvent action, lake water is therefore remarkably free from dissolved minerals and is consequently soft. The nature of the rock on which the water is collected naturally affects the nature

and amount of such solids. The water as brought into the basin by tributary streams may hold much matter in suspension, especially after heavy rain, but the greater part soon becomes deposited.

Reservoirs are made when it is desirable to increase the water supply of towns, and to ensure that there shall be no shortage in times of drought. They are simply artificial lakes made by damming up natural outlets of catchment areas. The water from reservoirs is similar to that obtained from natural lakes.

So far then we have considered what may be described as surface waters, though these may have contributions from sub-soil collections. The fate of the water after it sinks into the soil depends upon the character of the ground. Water, as it percolates through the pervious soil, takes up the carbonic acid that is present, which imparts to it the power to dissolve calcium carbonate, magnesium carbonate, potassium carbonate and sodium carbonate, and to a certain extent to act upon the silicates.

In addition to the mineral taken up, the water gathers a variable quantity of organic matter; this may be of a harmless nature or consist partly of excretal products from people and animals. All surface water, therefore, must be regarded with suspicion.

Wells are shafts or tubes sunk into the soil. They are of three kinds, *shallow, deep* and *artesian.*

A shallow well is a shaft sunk into pervious soil, and which collects water from close proximity to it. The term "shallow" gives no indication of the depth of the well, a shallow well may be 6 or 60 feet deep, though it rarely exceeds 40 or 50 feet. So long as the shaft does not penetrate an impermeable stratum, such as clay, it remains a shallow well, whatever its depth may be.

A deep well is a shaft sunk through, first, a pervious layer, and second, an impervious layer, and draws water only from below the impermeable stratum. Water which has reached this position has passed through the surface soil some considerable distance away, and has thus had sufficient time and opportunity to become purified by natural filtration. It must be clearly understood that surface water must be kept out of such a well for it to be a true deep well. This is done by lining the interior of the well with bricks faced with cement. This protection against the inlet of surface water, which is called steining, should in theory reach right down to the impermeable stratum, but in many cases it ceases before this depth is reached. The depth to which the steining is taken depends largely upon the nature of the soil and the pollution that is likely to take place.

Deep well water is pure if the well is properly constructed.

Like surface water it contains more gas in solution than does rain water, and in many instances it holds a considerable amount of dissolved solids and is therefore hard.

Artesian wells.—If there is a pervious layer of soil between two layers of impermeable strata its water will percolate to and be held by the second or deeper impermeable layer. If the formation of the land be that of a crater where the various strata run up to the surface at a higher level than the bottom of the basin, the water between the two impermeable layers will be held there under considerable pressure. If, therefore, this supply be tapped by boring, the water will spout up the shaft or bore tube. Such is an artesian well. The supply from these wells is sometimes enormous, two or more million gallons being obtained daily from some of the Australian wells. They are commonly sunk to a depth of 1500 feet, and may be much deeper. The water that issues from the deep borings may have a temperature of over 100° F. Artesian well water though pure often contains a high proportion of dissolved solids.

Springs.—An outlet of water at the surface is called a *spring.* A spring may result from a dip in the land cutting across an impermeable stratum, which thus appearing at the surface affords an outlet to the water that has gathered on it. Such water is essentially surface or ground water. It may be pure if the configuration of the land is such that a considerable depth of soil covers the stratum that holds the water. If, however, the soil is shallow, the water will appear at the spring without having undergone sufficient filtration, and may therefore be impure. These "land springs," or "dip springs" as they are commonly called, fail in periods of drought and "break" again after rain. If they soon run dry and soon break then they are shallow, and the water is of doubtful purity. If, on the contrary, the flow continues during dry weather, then the supply is a deep one.

Springs also appear from a fissure occurring in a stratum such as rock, thus letting the water underlying the rock escape. These are called "fissure springs." The water is pure and similar to that obtained from deep wells. Fissure springs are not liable to fluctuation like land springs. Another form of spring results from a geological "fault." A "fault" is where two strata of different formations join with a fissure at the junction. The water of a "junction spring," as it is called, issues at the fissure, and may have come from a distance or be merely surface water. Its character therefore depends upon the nature of the ground.

Ice water. — When water freezes a considerable amount of

its organic matter and air is extruded. This does not mean that ice is pure. It is usually purer than the original water, but it may contain pathogenic bacteria which freezing does not destroy. It is important to bear this in mind, especially in Eastern countries where large quantities of ice, often of doubtful origin, are used.

Ice water owing to its freedom from dissolved gases is unpalatable.

Distilled water. — This may be obtained from sea or fresh water. In either case it is pure, but is unpalatable. Distilled water as obtained on ships has often an unpleasant taste.

The Utility of Water from the Various Sources.

Because a water has a pleasant appearance and is palatable it is not necessarily wholesome, for water may be contaminated with sewage and yet be sparkling and pleasant to drink. Waters have been classified according to their palatability and wholesomeness by the Rivers Pollution Commissioners as follows :—

Wholesome,	Spring water,	Very palatable.
	Deep-well water,	
	Upland surface water,	Moderately palatable.
Suspicious,	Stored rain water,	
	Water from cultivated land,	Palatable.
Dangerous,	River water,	
	Shallow-well water,	

This classification must be applied with due regard to modifying circumstances, and must not be taken too literally. Upland surface water though usually pure may, on occasion, be badly polluted, and shallow springs may yield water as dangerous as that from shallow wells. The classification indicates generally what may and what may not be regarded as wholesome.

Rain water is chiefly used for washing owing to its softness. In the vicinity of towns it cannot be regarded as fit for drinking purposes, even if great care be taken in its collection. Surface or ground water, especially from low-lying land, is always to be looked upon as dangerous.

The utility of a water is influenced considerably by the amount of dissolved mineral that it holds. Waters containing much mineral matter are spoken of as hard, those containing little as soft.

Hardness of Water.

The term "hard" describes and owes its origin to the hard or harsh feeling that is obtained when soap is rubbed up with certain

waters that do not readily form a lather. The description "soft" is given to waters that form a soapy lather with ease, and which have a soft feel. Since a hard water does not readily form a lather with soap while a soft water does it follows that more soap will be required to produce a lather in a given quantity of hard water than in the same quantity of soft water; on the degree of hardness, therefore, depends the *soap-destroying power* of a water and, as will be shown later, this power of a water may be used to determine its relative hardness.

In order to understand clearly the soap-destroying power of water it is necessary to know how soap is made and the changes that take place when soap is rubbed up in normal pure water.

The natural fats and oils (an oil is a liquid fat) are insoluble in water, but if they are boiled with a solution of a caustic alkali in water they are split up into glycerol and an alkali salt of the fatty acid (soap). This change is spoken of as *saponification,* and is expressed as follows:—

$$\underset{\text{Tristearin}}{C_3H_5(C_{18}H_{35}O_2)_3} + \underset{\text{Soda}}{3NaOH} = \underset{\text{Sodium stearate}}{3NaC_{18}H_{35}O_2} + \underset{\text{Glycerine}}{C_3H_5(OH)_3}$$

In hot water the sodium stearate or soap and the glycerine are in solution, and the former is precipitated or "salted out" by the addition of common salt; it is then purified and forms the soap of commerce. When soda is used as the base, a hard soap is produced; when potash, a soft soap.

Both the hard and soft soaps are soluble in water, and they dissociate by hydrolytic cleavage into free fatty acid and free alkali (sodium or potassium hydroxide), forming an emulsion or lather which possesses cleansing properties.

Most natural waters contain in solution some of the earthy or mineral salts such as the carbonates, or rather bicarbonates, of calcium and magnesium; the sulphates and chlorides of calcium and magnesium; or iron or zinc salts. As the cleavage of soap into fatty acid and alkali occurs, the fatty acids combine with such compounds of calcium and magnesium as may be present, forming insoluble salts, which are precipitated as a "curd."

So long as there are compounds of calcium and magnesium available for combination with the dissociated fatty acids no emulsion will take place, and consequently little or no cleansing. The greater the amount of mineral matter held in solution in the water the more soap will be destroyed before a lather occurs, the soap-destroying power of a hard water, therefore, will be greater than that of a soft water.

A hard water may be described as one which contains dissolved mineral matter in undesirable quantity. Hardness is of two kinds, *temporary hardness* and so-called *permanent hardness.*

Temporary hardness is due to the presence in the water of the bicarbonates of calcium and magnesium, and is so called because it can be removed by simply boiling the water. When rain descends it absorbs from the atmosphere some of the carbon dioxide, the acidity thus gained is sufficient to dissolve calcium and magnesium carbonate, insoluble in non-acid waters, and to form the bicarbonates. The bicarbonates thus formed remain in solution, but when the water is boiled the CO_2 is driven off as gas, the bicarbonate is reduced to the carbonate and, being thrown out of solution, is precipitated. It is this precipitated calcium or magnesium that constitutes the scale or fur in kettles, boilers, &c.

The eroding action of acid rain water on calcium carbonate is well seen in the pitting and crumbling away of marble tombstones in cities.

The following equations will illustrate what has been said above:—

$$\underset{\text{Carbonic anhydride}}{H_2O + CO_2} = \underset{\text{Carbonic acid}}{H_2CO_3}$$

$$\underset{\text{Calcium carbonate}}{CaCO_3} + H_2CO_3 = \underset{\text{Calcium bicarbonate}}{CaH_2(CO_3)_2}$$

On boiling the water the calcium bicarbonate becomes reduced as follows:—

$$CaH_2(CO_3)_2 = CaCO_3 + H_2O + CO_2$$

The sulphates and chlorides of calcium and magnesium and any nitrates that may be present are soluble in water whether CO_2 be present or not; therefore they are not thrown out of solution when the CO_2 is driven off on boiling. Hardness due to the presence of these salts is on this account called *permanent* as compared with the *temporary* hardness due to the presence of bicarbonates, which are readily removed by boiling. The sum of the temporary and permanent hardness is called the *total* hardness.

Iron in the form of ferrous carbonate such as is found in chalybeate waters adds to the permanent hardness; so also may the zinc salts and silicates.

Waters differ greatly in degree of hardness according to the nature of the soil through which they have percolated and from which they are collected. Those collected from the igneous or

oldest rocks are the softest, while those from chalk and limestone are the hardest. Intermediate between these two extremes are the moderately hard waters collected from the sandstones and shales.

The Rivers Pollution Commissioners tabulate the relative hardness of waters according to their source as follows, descending from softest to hardest:—

(1) Rain water; (2) upland surface water; (3) water from cultivated land; (4) river water; (5) spring water; (6) deep-well water; (7) shallow-well water.

Shallow wells may, however, contain soft water.

The hardness of a water may be indicated conveniently by (1) expressing the number of grains of calcium carbonate per gallon of water as so many degrees of hardness; or (2) in parts of calcium carbonate per 100,000, 1 per 100,000 being 1 degree. The first method is expressed as so many "degrees Clark." The latter method is being generally adopted. Since one gallon of water weighs 70,000 grains, degrees Clark can be readily converted into parts per 100,000 by multiplying by 10 and dividing by 7. To convert parts per 100,000 into degrees Clark, multiply by 0·7.

The following table is a classification of water according to its hardness:—

Description.	Parts of $CaCO_3$ per 100,000.	Degrees Clark.
Very soft	5	3·5
Fairly soft	5 - 10	3·5 - 7
Medium	10 - 15	7 - 10·5
Fairly hard	15 - 20	10·5 - 14
Hard	20 - 30	14 - 21
Very hard	30 and over	21 and over

The Significance of Hard and Soft Waters. — Hard waters possess many economic drawbacks. When water is heated sufficiently to drive off the CO_2 the calcium and magnesium carbonates are precipitated, forming the "fur" in kettles and boilers. As this deposit increases there is a corresponding decrease in the available heat, with consequent financial loss. "Boiler scale" is due to the deposition of the sulphates, which become thrown out of solution when the water is heated under pressure. The wastage of soap when hard water is the only water available for washing purposes is very great compared with what it would be if the water were moderately soft. With hard waters the waste pipes from kitchens and lavatories become coated with the insoluble stearate, palmitate and oleate salts, which on decomposing make the pipes foul.

It has been frequently stated that very hard water is the cause of indigestion and malnutrition with both animals and people, and it is said that horses compelled to drink hard water develop a dry, hard coat and become dyspeptic. It has even been suggested that the perpetual drinking of such a water results in the formation of intestinal calculi, a supposition that is devoid of proof. Very soft water, being deficient in lime, has been considered to be one of the causal factors of rickets, but the lime available in moderately hard water is scarcely worth consideration compared with the demands of a growing child or animal. It is now known that rickets and soft teeth are more closely associated with vitamine-deficient foods than with supposed calcium deficiency. For all general uses a moderately hard water, one containing about 12 parts of calcium carbonate per 100,000, is to be preferred to one either very soft or very hard. For making sheep-dips, solutions of disinfectants and for similar purposes a soft water should be chosen.

Softening Hard Water. — As hard water is undesirable for domestic and most manufacturing purposes, measures are taken to reduce the hardness before it is delivered to the consumer. The temporary hardness due to calcium and magnesium carbonates can be removed by boiling when only small quantities have to be dealt with, but this leaves the water deficient in dissolved gases and therefore insipid and unpleasant to drink. When large quantities have to be softened, as for instance the main water supply of a township, such a method as boiling is impracticable.

As the calcium and magnesium carbonates are held in solution as bicarbonates by the CO_2 in the water, they become precipitated as the carbonates on the addition to the water of any substance that will unite with the CO_2. This is what occurs when slaked lime is mixed with the water. This method was brought out by Dr. Clark, and is known as *Clark's Method of Water Softening.* The changes that take place are as here shown :—

$$CaH_2(CO_3)_2 + Ca(HO)_2 = 2CaCO_3 + 2H_2O$$
$$MgH_2(CO_3)_2 + Ca(HO)_2 = MgCO_3 + CaCO_3 + 2H_2O$$

1 oz. of lime is added to every 100 gallons for each grain of calcium per gallon.

The calcium carbonate is more readily thrown out of solution than is the magnesium carbonate, and Clark's process is therefore especially adapted for the treatment of water having a chalk origin. The slaked lime does not remove all the calcium carbonate, and it is found that about two grains per gallon remain in solution. In order to get rid of the magnesium carbonate excess of lime has to

be added so as to form the hydrate of magnesium, which is less soluble than the carbonate.

The lime, in addition to removing the calcium and magnesium, also causes the precipitation and settlement in the tanks of most of the iron and manganese that may be present, and, what is of great importance, a great deal of the organic matter and water fauna and flora. Clark's process, therefore, purifies as well as softens the water.

As the treated water readily absorbs CO_2 from the air and as the sedimentation is naturally a slow process, it is hastened by drawing the water through filter cloths as in the Porter-Clark modified process.

Permanent hardness due to the presence of sulphates and chlorides of calcium and magnesium may be reduced by the addition of washing soda (carbonate of soda), so that there are formed sodium sulphate, sodium chloride and calcium carbonate :—

$$CaSO_4 + Na_2CO_3 = Na_2SO_4 + CaCO_3$$
$$CaCl_2 + Na_2CO_3 = 2NaCl + CaCO_3$$

Permutit Process.—The name given to this process is taken from the Latin *permutare,* to exchange. It has been found that when hard waters pass through certain soils containing zeolitic minerals, chiefly silicates of aluminium and calcium, they become softened. Dr. Thresh* found that very hard chalk waters when they percolate through the Thanet sands under Essex and London lose their calcium carbonate and magnesium sulphate, which are replaced by sodium carbonate and sodium sulphate.

This exchange is effected by a mineral contained in the soil. Gans, of Berlin, made artificial zeolites, "sodium permutit," by fusing silica, alumina, and sodium carbonate, "a hydrous meta-silicate of sodium and aluminium," being the product to which he gave the name of "Permutit."†

Permutit possesses the power of exchanging its base for another base. For instance, if water containing calcium carbonate is passed through sodium-permutit the permutit parts with its sodium and takes in exchange the calcium. Thus the permutit becomes calcium-permutit, and the water contains sodium carbonate. When the permutit has parted with all its sodium it can be regenerated by passing through it a solution of common salt, the permutit taking the sodium and liberating in the water a soluble calcium salt. By this way the permutit can be used over and over again. Very hard

* *The Examination of Waters and Water Supplies,* 1913.

† *Water Supplies,* Rideal, 1914.

waters can be completely softened by passing them through permutit. Dr. Thresh gives evidence to show that no harm results to people from habitually drinking water containing the unusual amount of sodium salts that permutit treated waters and naturally softened waters contain. He points out that the permutit system of water softening is the only one that is applicable to any kind of water.

THE ACTION OF WATER ON METALS.

Plumbo-Solvency of Water.—Certain classes of water possess a solvent or an eroding action on lead. Animals or people drinking water that has been conveyed any distance in lead pipes, or has been stored in lead cisterns or has stagnated for any period in lead pipes may, if the water is lead-solvent, take into their system minute quantities of lead. Lead, however, is cumulative, so that if water containing the merest trace of lead be habitually drunk there will come a time when toxic effects will be produced and symptoms of lead poisoning apparent. Serious cases of lead poisoning have occurred in both animals and man, and the cause and nature of the illness has not always been suspected.

Water derived from peat moorlands is often acid and is therefore lead-solvent. During a dry period water coming from the moors is chiefly of spring origin and is not acid. The first water washed from the moors after a dry period is very acid, and it contains the water that has been lying stagnant in pools and marshes. This is most dangerous. The acidity lessens after the ground has been well washed by heavy rains.

Waters well oxygenated, and those containing much free CO_2, are lead-solvent, and so also are waters with much organic matter or nitrates in solution, especially if the water is soft. Rain water dissolves lead.

Hard water attacks new and untarnished lead, but there is soon formed a coating of basic lead carbonate which prevents any further action.

Acid water containing free CO_2 is lead-solvent, while neutral water containing much dissolved oxygen has an erosive action.

It is important to remember that the lead-solvent power of a water is not constant, a moorland water when tested at one season may be free from any objectionable action while a few months later it may be quite dangerous.

Whenever it is known that a water may have a lead-solvent action the use of lead service pipes or lead containers should be avoided. The water may be treated with lime or chalk to neut-

ralise the acidity. For public supplies the water coming from a known acid area is usually cut out or provision is made for the exclusion of the first of the flood water as it comes from the moors.

Action on other Metals.—Water containing much carbonic acid and oxygen has an eroding action on iron and causes pitting of delivery pipes; the action is more marked in soft waters than in those containing much lime. The addition of lime acts as a preventive. The carbon dioxide in the water causes the formation of ferrous carbonate which, in the presence of air, becomes oxidised into the oxide so that CO_2 is again liberated. The calibre of the pipes may be greatly reduced by the incrustations of the oxide or the iron may become so pitted and thinned that the pipes burst. There is no reason to believe that iron-containing water is harmful to animals, but the presence of iron is favourable, and indeed necessary, for the growth of *Crenothrix* which is often very troublesome in water pipes.

Zinc is acted on by some waters, yet zinc-lined troughs are used extensively without apparently causing illness.

Other metals are sometimes found in water. Thus arsenic used in the manufacture of sheep-dips and weed-killers may gain access to water supplies if carelessly used in the vicinity of wells or if the dripping ground at a dipping tank should drain through the subsoil by fissures into a well.

The Storage of Water.

Wherever there is a public water supply to a community, provision is made for the collection and storage of such a quantity as will meet the demand during the dry season. Storage of water besides maintaining the supply for service greatly improves its quality, unless the water is already pure, in which case it may deteriorate.

Storage reservoirs are of two kinds, *impounding* and *service*.

Impounding reservoirs are the lakes, natural or artificial, that hold the drainage of a watershed. From these the water is conveyed to service reservoirs. The water as it flows into an impounding reservoir is more or less contaminated according to the condition of the ground it has washed. If the area is not heavily manured and is not polluted by human excreta the organic matter is mainly of vegetable origin. Having entered the reservoir, the organic matter in the water settles to the bottom and carries down with it a very large proportion of the bacteria.

The number of bacteria is also reduced by the lack of food, and they themselves act as food for the infusoria present in the

water. Storage alone, however, does not entirely eliminate the micro-organisms.

If pathogenic bacteria gain entrance to pure water, that is water free from such organisms as naturally feed on them, up to a certain point they multiply more rapidly than in impure water.

Turbid water becomes clarified by storing so that its general appearance is improved, but peaty waters retain some of their colour. Storage also reduces the hardness and the amount of free and saline ammonia.

In impounding reservoirs there is always some vegetable growth where the water is comparatively shallow and where light can penetrate. This, as it decays, adds vegetable organic matter to the water, which is undesirable.

In the deeper parts where light cannot penetrate there is no floral life, and it is for this reason that the sides of storage reservoirs are made practically vertical. In service reservoirs there is no rise and fall in the depth of the water as is the case with impounding reservoirs, so that there is less opportunity for plant growth.

With both impounding and storage reservoirs precautions are taken to prevent the entrance of sewage and waste drainage.

Storage of Domestic Supplies.—With the possible exception of houses and premises provided with a constant supply of water direct from the main, some provision is necessary for the storage of a sufficient quantity of water to ensure that there will not be a temporary shortage. Storage cisterns may be of galvanised iron, lead or slate. Lead is unsuitable where the water has a lead-solvent or lead-erosive action. Slate is a good material, but it is difficult to make satisfactory joints.

Whatever type of cistern is used the water should be run off if it has been in the tank for any length of time. Cisterns should be placed so that there is convenient access to them, and they should be inspected periodically. They should be covered over to prevent the entrance of vermin and dirt, and they should be ventilated.

When a cistern is cleaned out, the lead or zinc surface should not be scrubbed as this removes the protective coating.

On farms not receiving public water a supply is often pumped up from a deep well by a wind-driven force pump and conveyed to the farmhouse cistern, and to one or more tanks situated at convenient centres for distribution. These tanks act as feeders to drinking-troughs distributed about the farm, such as in the cattle courts, stable-yard, &c. They are fitted with ball-cocks, and are self-filling from the main feed tank. The ball-cock should be built into the wall or so covered over that the water will not get frozen in

the winter. The tanks or troughs should be of iron or glazed stoneware. Wood troughs should not be used as they become foul.

Filtration of Water.

While the mere storage of water in reservoirs and service tanks considerably improves its quality and appearance, it is not in itself a sufficient safeguard when the water is to be used for domestic purposes. The completion of the purifying process is done by *filtration,* and in addition it is sometimes *sterilised.*

All surface waters, those collected from a watershed and impounded, all river waters and sub-soil waters must be considered as exposed to the risk of contamination, and therefore requiring filtration.

Filtration may be *natural,* as when the water finds its way to the deeper strata through porous soil.

During the percolation the organic matter and bacteria are arrested and removed, and, if the percolation has lasted a sufficient time and the water gone through a sufficient depth of soil of suitable character free from any possible contamination, it becomes purified. But natural filtration is not always to be depended upon, and some spring waters that theoretically should be pure are not uncommonly found to be polluted. Foul water has been known to travel long distances underground along the top of an impervious ledge to find an outlet in a previously pure supply.

Artificial Filtration as at present practised is of two kinds, *Open Sand Filtration* and *Mechanical Filtration.*

Sand Filtration.—Sand filtration may be described as a copy of natural filtration. While there is considerable variation in the details of filter bed construction, in principle they are the same. The bed itself is made of cement concrete throughout, and is provided with an inlet and a run-off. At the bottom of the bed is placed a layer of bricks between which run the outlet channels; on the bricks is laid a layer of broken stones or large gravel of about 1 inch mesh to a depth of 6 or 7 inches; above this a layer of finer gravel, usually of ½ inch mesh, to a depth of 4 or 5 inches; then comes a layer of coarse sand 2 feet 6 inches deep, and on the top of this is a layer of finer sand 8 or 9 inches deep. Such is the construction of a filter bed when newly made. As it is, however, it is not an efficient filter, as the sand in the clean state will let organic matter and bacteria pass through. As soon as the filter bed is completed water is let in gently, so as not to disturb the sand, until it is 4 or 5 feet deep. Filtered water is let in from below, and unfiltered from above.

When filtration begins, the sand, acting as a strainer, holds back the coarser particles which fill the interstices, and so prevent the passage of finer particles. Eventually the sand becomes covered with a layer or carpet of organic matter, algæ and bacteria. As the formation of this carpet progresses, the rate of filtration becomes slower and more efficient. It is this film of organic matter that makes a filter efficient. When the filter has been in use for some time the film becomes so dense that filtration is too slow, then the filter is run dry, the film removed, the top layer of sand washed and relaid, and filter is ready once more. The efficiency of a filter depends largely upon the height of the superimposed water, if it is too great then filtration is too rapid for satisfactory results. The rate at which the carpet or film forms depends upon the nature of the water; a filter may last a few days or as many months.

Mechanical Filtration. — For industrial purposes it may be necessary to have water that is free from sediment but which need not be pure. All that is required is to remove gross organic matter and sediment; the filtration is therefore done more rapidly and without the formation of an organic film. Rapid mechanical filtration of high efficiency may, however, be effected by making an artificial film. This is done by adding to the water a coagulant. Sulphate of alumina is commonly used for this purpose. It reacts with the carbonate of lime and of magnesia in the water, and forms aluminic hydrate, a gelatinous substance that carries down bacterial and other impurities as it settles. This method is specially suitable for water containing much clay. Very soft water, to which the sulphate of alumina alone is added, does not yield the necessary film, as there is not sufficient calcium carbonate for the reaction to take place. Lime is therefore added to very soft waters. The following equation shows the chemical reaction :—

$$Al_2(SO_4)_3 + 3CaCO_3 + 3H_2O = Al_2(OH)_6 + 3CO_2 + 3CaSO_4$$

The above equation shows that the temporary hardness due to the calcium or magnesium carbonate is converted into permanent hardness by the formation of the corresponding sulphates.

The film formed by the slow sand filtration method is an organic one; that formed by the use of chemical coagulants is inorganic. The latter is capable of standing more rough usage than the former; the water stands at a greater height in the bed and exerts a greater pressure on the film. Thus filtration proceeds at a greater pace.

Impure water when it is filtered is improved in appearance, colour, taste and odour. Its organic matter is reduced and its

bacterial content may be reduced 99 per cent. The micro-organisms that are pathogenic to man are more easily killed in the film than are the harmless ones, and the *Bacillus coli,* which is always found in sewage, is taken as the index of the efficiency of the filtration, because if this organism is absent from filtered water it may rightly be presumed that pathogenic organisms are also absent.

Sand filtration keeps back from the service pipes the fauna that are found in storage reservoirs and which, if they gain entrance to the pipes and cisterns, cause a lot of trouble and spoil the appearance of the water, even if they do no actual harm.

The film is sometimes impaired by the burrowing of worms, small eels and sticklebacks, so that on occasion water may pass through only partially filtered. Gas bubbles, the result of animal life in the film, may leave a ruptured surface on the film when they break loose.

While the purification of water for domestic use is very important, the same precautions need scarcely be taken for farm animals or for general use on farms, were it not that impure water, when used for washing out dairy utensils, may be the means of starting an epidemic of typhoid.

If water containing much suspended solid matter, muddy water, is habitually drunk by animals it leaves an ever-increasing deposit of silica, mica, &c., in the alimentary tract. This is a cause of colic, constipation and, in the case of mica which forms a coating on the mucous membrane, mal-nutrition.

Water of this nature can be roughly filtered by passing it through a gravel and sand bed or, in cases of emergency, through coarse canvas.

Sterilisation of Water.

Subsequent to filtration, the purification of the water may be completed by *sterilisation.*

This is not always necessary, but is probably advisable for a public supply when the water is used for drinking. Each supply must necessarily be considered on its own merits. In the case of dairy farms situated in the country remote from public conveniences the water used for all purposes is often drawn from shallow wells and other doubtful sources. Artificial filtration of such an individual supply is not practicable, so that sterilisation must be substituted.

The methods adopted for the sterilisation of water may be divided into two classes, *physical* and *chemical.* The *physical methods* include the use of *heat, light* and *electricity.*

Heat.—Except for domestic purposes and for sterilising water on a small scale heat is not used. It is too expensive and the product, when the water is boiled, is devoid of gas and is consequently insipid. When boiled under pressure it "boils" at a higher temperature than when exposed to the air, and all its gas content is not dissipated. For general purposes the use of heat may be discounted. It is, however, of great value under certain circumstances as when there is reason to believe the filters have become temporarily faulty or when, owing to heavy flooding, surface water has gained entrance to wells or springs. Where such an accident as the latter occurs warning is usually given by the turbid appearance of the water.

Light.—The ultra-violet rays of direct sunlight are germicidal, but their action is limited to a very little way below the surface of the water. The ultra-violet rays are sometimes used for the final purification of public water supplies. There are many difficulties attending its use. It is practically useless with anything but clear water as suspended matters arrest the rays.

Chemical Sterilisation.—Sterilisation of water by the use of chemicals should always be preceded by some form of filtration so as to remove the grosser particles of organic matter. The chemical substance used must not impart a disagreeable taste to the water nor make it harmful to animals or people, while at the same time it must possess sufficient germicidal power to effect its purpose. The following substances are those most commonly used.

Potassium Permanganate.—Permanganate of potassium decomposes in the presence of organic matter yielding nascent oxygen.

It is a feeble disinfectant in water, but has a specific action on the cholera vibrio owing to the lethal effect of oxygen on this particular organism. A better reaction is obtained by the addition to the water of some dilute acid. This treatment is not used on a large scale but is sometimes adopted for the disinfection of wells and water tanks. The amount of permanganate added must obviously vary with the degree of pollution. Lelean* says "The treatment of wells is effected by adding to each gallon of water 60 grains of permanganate with 3 drachms of strong hydrochloric acid; leaving for twenty-four hours; pumping until the water is colourless; removing dead aquatic fauna."

Sodium Bisulphate. — The addition of sodium bisulphate to water has for its object the liberation of sulphuric acid. The salt is put up in the form of tablets and is flavoured with lemon and saccharin. The strength recommended is 15 grains of the salt

* *Sanitation in War*, 1919.

to a pint of water; this concentration is said to destroy vegetative organisms in half an hour. This method of purification has been used with success by troops and travellers, but it has no application in veterinary practice.

Chlorine. Bleaching Powder.—Of the halogens chlorine is the only one of practical interest for the sterilisation of water. It may be used in one of three ways:—as chlorine gas, as bleaching powder, or as sodium hypochlorite.

When chlorine is liberated in water a certain proportion is consumed by the organic matter, and any iron and sulphur compounds present, so that the amount that is available for the destruction of bacteria, that is for sterilisation, will be the total quantity generated less that taken up by the other substances. In practice this is carefully estimated. Bleaching powder when mixed with water yields hypochlorous acid and nascent oxygen; it is a more powerful oxidising agent than chlorine gas and produces relatively more oxygen. The following equations explain the reactions that take place:—

$$CaOCl_2 + H_2CO_3 = CaCO_3 + H_2O + Cl_2$$
$$CaCO_3 + H_2O + 2Cl_2 = CaCl_2 + 2HClO + CO_2$$
$$2HClO = 2HCl + O_2$$

When bleaching powder is used for the purification of water it should be added in such quantity as to yield at least one part per million of available chlorine, that is chlorine that is not used other than for the destruction of bacteria. The time allowed should be half an hour. Chlorinated water has often a disagreeable taste. According to Lelean* two parts of chlorine per million of water can be used without the risk of an objectionable taste. Subsequent exposure to the air removes the taste and when water is chlorinated on a large scale it is allowed to fall in cascades for thorough aeration.

Bleaching powder added to foul ponds readily purifies the water and destroys the algae.

Sulphate of Copper.—Sulphate of copper has a very destructive effect upon algae. One part of the salt to a million parts of water is sufficient to rid a water of most of its algae. Provided that the water does not contain too great an amount of organic matter, one part to 400,000 will destroy typhoid bacilli in twenty-four hours.

The Amount of Water Required by Domestic Animals.

The amount of water required daily by domestic animals depends upon their size and functional activity, the nature of the

* *Sanitation in War,* 1919.

food and the season. A horse under average conditions will drink from 6 to 8 gallons during the day, but if fed chiefly on fresh green grass he will naturally drink less. Provision should be made for 8 gallons for drinking, while for general stable purposes an additional 6 or 8 gallons may be necessary.

Cattle require fully as much as horses, and milch cows giving a full yield of milk and on dry winter fare without roots or mashes need 10 gallons or more a day. It has been shown that physiologically a cow requires nearly four times the amount of water (given as water or in the food) for the milk she secretes. A cow giving 4 gallons of milk a day would, according to this, require approximately 13 gallons of water daily. If fed heavily on roots a bullock will actually take in more water than is required, and many feeders do not give their fattening stock water. A further 4 gallons per head should be allowed for cleansing purposes in a byre.

Breeding pigs were found by Dietrich to require from 8 to 10 lbs. of water per 100 lbs. live weight. Fattening pigs, he says, should have 13 lbs. of water per 100 lbs. at two months' old; 10 lbs. from three to three and a half months; and about 5 lbs. when eight months of age.

There is no doubt that in this country many pig-feeders compel their pigs to take in far too much water by giving practically all the food in the state of a thin soup. The better practice is to feed comparatively dry food and supply clean water for the animals to drink as they need it.

Fowls and ducks should have an unstinted supply of clean, fresh water, and if it is given in pans these should be emptied and cleaned daily.

While some stockowners force their animals to take more water than they really need, as with excessive root feeding and the perpetual feeding of slops, some unfortunately fail to see that their stock get a sufficient and regular supply. When roots are scarce and most of the feeding for cattle is dry veterinary practitioners find that impaction of the rumen and stomachs is very common. It is the opinon of many country practitioners that stall-tied cattle are often kept short of water, and thus suffer unnecessary disease.

Frequently all classes of domestic animals are kept without water for too long a period, with the consequence that when they get access to it drink more than they require. Animals cannot thrive under such unnatural conditions.

If they do not get sufficient water for their physiological needs they do not eat as freely of dry food as they should for good progress to be made. This fact is not often recognised in the feeding of

calves, but Mackenzie has given it as his opinion that the growth of calves is often retarded through their having too little to drink. When their milk has been curtailed they do not eat enough dry food to promote proper growth. Their fluid allowance should be made up to two or three gallons a day, according to their size.*

Stock frequently suffer from a temporary water shortage when on train transport, though not commonly in this country. By the Water Supply on Railways Order, 1895, railway companies must supply water at certain scheduled stations to all animals carried, or about to be carried, by rail. Animals travelling to market by road in the summer often suffer from thirst.

The Effect of Sewage-Polluted Water on Animals.

A great many cases of illness and death among horses and cattle have been attributed to the animals drinking water polluted with sewage effluent. Many such cases have been taken to the law courts and damages claimed against persons responsible for the pollution, and the claimants have met with a responsive sympathy. It is not a difficult matter to induce a body of jurymen to believe that because water contains a certain percentage of sewage it must be poisonous, and, therefore, the cause of the particular illness from which the animals happen to be suffering.

Instances of so-called sewage poisoning are usually confined to cattle and horses, and the symptoms said to be manifested most commonly are abortion, diarrhœa, indigestion, general ill health and an unthrifty condition. Sometimes sudden death or death following but a short illness is also recorded as occurring after an animal has drunk from a foul stream or pond. More commonly, however, the *disease* is of a more prolonged nature, being rather in the nature of general unthriftiness than an actual and obvious disease, but the owner of the animals can usually assert that the symptoms, often of a vague character, began shortly after the particular water was first used.

The state of our knowledge concerning the effect on animals of drinking sewage-polluted water is not satisfactory. While one is not prepared to say that the drinking of such water by animals cannot cause disease, or at least ill health, no evidence has yet been produced, so far as the author knows, that sewage-polluted water does definitely cause illness. It is extremely improbable that the causal agents of specific animal diseases are conveyed in ordinary sewage, anthrax from effluents from tanneries and wool-washing

* *Cattle and the Future of Beef Production in England,* 1919.

premises that gain access to sewers excepted, and human typhoid is non-existent among our animals. But, is the presence of specific organisms that are known to be pathogenic necessary for the production of "ill health"? Is it safe for people to drink sewage known not to contain the specific bacteria that are pathogenic to mankind? It has been held in court that damage to health of cattle through pollution might be established without any special ailment being proved, but one would want to be satisfied that every other possible cause of illness had been eliminated. It has been suggested that the ingestion of putrefactive bacteria and their products, such as are found in sewage, cannot do harm to animals as the normal and healthy alimentary tract is teeming with putrefactive organisms and that a few more can do no harm.

While one is not prepared to accept this reasoning as altogether conclusive, it is certainly a fact that animals time and again drink very filthy water and water containing sewage, and *apparently* suffer no ill at the time. Cows on sewage irrigation farms constantly eat, under the soiling system, grass fresh cut from the irrigation beds, and frequently wet with undiluted sewage. The author knows of such a farm that is particularly foul and "sewage sick," the grass of which, when it is cut and fed to the cows, has a most unpleasant smell, and yet the animals apparently suffer no ill. That it is undesirable for dairy farms to be located on sewage farms few will dispute, but the fact remains, that so far as the cows are concerned, there appears to be nothing against the practice. This is a strong argument, unwelcome though it is, that sewage water is harmless to stock. The position, in short, appears to be this, that though there is no real proof that sewage-polluted water is harmful to animals, no one, on the other hand, can say with certainty that it is free from danger. Whatever proof there may or may not be with regard to definite illness produced by drinking filthy water, the fact remains that pure water is always more desirable than polluted water, as we know that the former cannot cause harm, while the latter *may* do so.

Lack of proof that sewage-polluted water does cause illness does not, fortunately, leave the way open for public authorities or private persons to pollute streams as this is prohibited by the Rivers Pollution Prevention Act.

The Examination of Water and Water Supplies.

There is a very common idea that if a person fills a bottle with water from a well, or a stream, or out of a tap and sends it to a chemist, the chemist, by making an analysis, can say with certainty

whether or no the water is fit for drinking purposes. One analysis of a particular supply may give very valuable information that would lead to the condemnation of the water that would otherwise pass without suspicion, notwithstanding the most careful examination of the source of supply. On the other hand pollution by sewage may be, and often is, of an intermittent character. Such intermittent contamination is sometimes of a very dangerous nature to people if not to animals, and it may escape detection if the sample for analysis is taken between the periods when contamination occurs. A shallow well, for instance, after a long period of dry weather may yield a water that by analysis would be described as "pure and wholesome," but which, owing to faulty steining or other defect in construction, might be seriously polluted with sewage matter washed through the soil after heavy rain. A newly constructed well would almost certainly be condemned if the potability of its water is considered only on the merits of a sample taken before the water that has collected during construction, and for some time after, has been withdrawn. Time must be given for a new well to cleanse itself. The examination of a water supply is not such a simple process as many think.

The methods used for the examination of water include *Physical, Chemical, Microscopical,* and *Bacteriological* tests, and lastly the *Interpretation of the Results* of the tests.

Physical Examination includes the examination of the water itself and the source of supply.

Examination of Supply.—The mere examination of the source of a water is often in itself sufficient to condemn it without taking the matter any further. The examination of the supply and its surroundings is not, however, sufficient to pass a water as "pure and wholesome."

The veterinary practitioner should make it his business to note the source of supply of the water on farms with which he may be connected. It is true that to fully understand water supplies and the possibilities of their pollution a more than passing knowledge of geology is necessary. But it is also true that with but an imperfect understanding of geology the practitioner may acquire much valuable information concerning the water supplies of his district.

If the water is supplied from the public water works, probably all that the veterinary practitioner need do is to note its degree of hardness. If very soft and acid, as when coming from moorland, it is liable to attack lead, and if it is conveyed about the farm in lead pipes it may be well to warn the proprietor of the risk involved.

If the water is excessively hard it will probably be found that some provision has been made for the collection and storage of rain water. If this supply is drawn upon solely for domestic purposes, as for clothes washing, no attention need be paid to it so far as the veterinary surgeon is concerned, but if it is used in connection with the dairy or for the live stock or for the making of sheep dips or for similar purposes then it should be examined.

The conditions under which rain water is stored in the country are sometimes very objectionable. The author well remembers inquiring into an outbreak of disease among a herd of milking goats in Devonshire. The owner was under the impression that rain water was the correct thing to give them, and had stored for this purpose a quantity in a large vat. When the contents of the vat were stirred up the smell was abominable. Many stockowners have the notion that any filthy water is good enough for animals to drink and yet, curiously enough, they are not backward in blaming a water supply for causing abortion and other illness when the supply is not under their own control.

Rain water is sometimes stored in an underground tank to which is attached a so-called filter-bed through which the water passes before it enters the tank. This is an unsatisfactory method of storing water, as the filter soon gets foul and rarely receives attention. Attempts to store water in underground tanks after it has been used for cooling milk have not met with success, the reason being that the water from washing the outside of the cans becomes dirty and contaminated with bacteria, and the subsequent storage facilitates their multiplication.

The examination of surface supplies, that is water from ponds, streams, ditches and the like, is often of great importance, as all these sources are peculiarly liable to pollution from sewage and other objectionable matter.

The ways in which surface waters become contaminated are truly many and varied. Sewage may be discharged direct into a pond or ditch or other surface supply without any pretence at previous purification. In the country drainage into a pond or ditch is often the easiest way to get rid of sewage, and there consequently it goes. Such surface collections of water have from time immemorial been the favourite burial place of cats and dogs, while shepherds too frequently throw dead sheep into a handy stream as the easiest way to get rid of them. The author was called to a farm to make a post-mortem examination on a bullock (a lightning claim was meditated), and found the dead beast with its head and forequarters immersed in a stream that ran through neigh-

bouring farms. For all the farmer knew, or apparently cared, anthrax or other dangerous disease might have been the cause of death. On another occasion two sows were found "buried" in sacks in a deep ditch, and their presence was only revealed when the water drained away. Post-mortem examination showed unmistakable swine fever lesions.

The examination of the source of supply should not be limited to the immediate locality. It may be necessary to trace back a stream or ditch when pollution is suspected in order to detect the cause of the trouble, if such exists.

Some sources of deliberate pollution are difficult to detect, soil pipes discharging into streams and ditches are sometimes so hidden that the most careful and thorough search would be necessary to reveal their presence. The following instance is typical of what sometimes occurs :—A detached villa in the country disposed of its sewage by discharging it into a large cesspit at the bottom of the garden. The garden was separated from an adjoining dairy farm by a ditch through which ran a small stream of water. The cesspit was about three feet from the ditch, and discharged its overflow into it. The ditch ran through the hedge into the farmer's cow park, and this was the water that the animals drank and through which they waded daily to their milking shed. When the author became acquainted with the place the pit had not been cleaned out for nine years and though the sanitary authorities were fully aware of the condition they seemed quite unperturbed.

The possibility of sheep-dipping tanks leaking or draining into streams and other water supplies should be considered when a site is being chosen for their construction.

Proximity of a dipping tank to a common water supply is very dangerous and should not be permitted, as many sheep dips contain arsenic. At least one instance is recorded where the water of a stream supplying a public reservoir became polluted and the trout were killed off below a dipping tank that was situated close to the stream.

Examination of Wells and Springs.—The well-water supply of farms and other country houses often leaves much to be desired from the sanitarian's point of view. The wells are often of the shallow type, that is they collect surface water, are badly constructed, imperfectly protected and, consequently, frequently liable to serious pollution. Many of these wells were built before the importance of clean water was understood, so that little or no provision was made to exclude the surface water. Indeed, at the present time there are local builders in isolated country places

who sink wells in any spot that happens to be most convenient to them, without any regard to proximity of dangerous soil-washings, and make the wells rubble-steined so as to let in as much of the surface water as possible, the object, of course, being to save labour and expense in deep sinking and in steining. But it must be clearly understood that, because a well-shaft does not penetrate an impervious stratum, the water collected is necessarily dangerous. A shallow well, if sunk to a sufficient depth, which varies with the nature of the soil, and has the upper part properly steined so as to exclude the real surface water, may, and often does, provide a water of excellent quality.

The construction of the well is the all-important factor.

Dr. Thresh says that, in the large majority of cases, where shallow wells yield polluted water it is due to defects in the construction of the wells, and for the guidance of those about to sink wells he points out that the water which enters at a depth of 6 to 12 feet, depending upon the porosity of the soil, is usually efficiently filtered and purified; that water entering at less depth is nearly always liable to be imperfectly filtered and unsatisfactory in quality; and that the nearer the ground surface at which water can enter, the greater the danger of pollution. The upper 6 to 12 feet should be water-tight and the top should be so finished off that no surface water can possibly gain access.

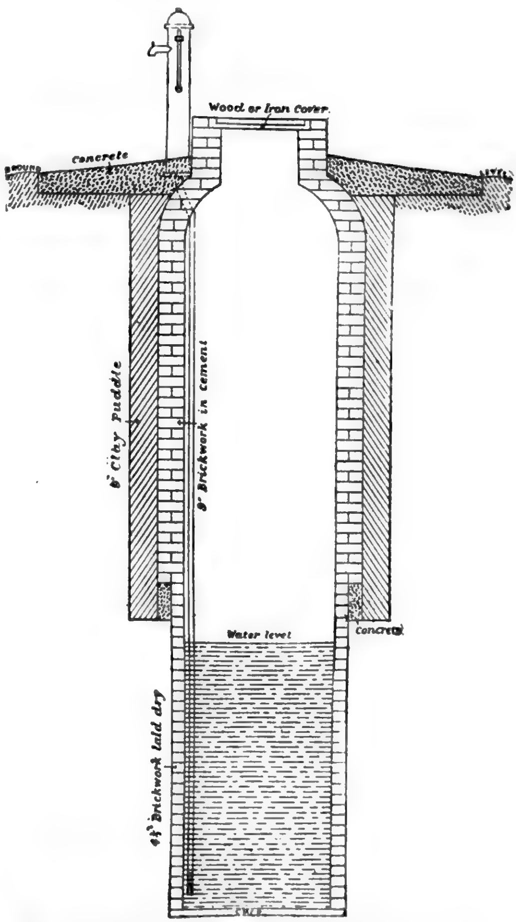


Fig. 1.—Showing a Correct Method of constructing a Shallow Well (Thresh).*

* *The Examination of Waters and Water Supplies,* by J. C. Thresh, 1913, J. & A. Churchill.

The top of the well should be raised 6 to 12 inches above the ground and covered with a proper flagstone or iron cover.

Farm wells are very liable to pollution, especially after heavy rain, from the washings of cattle-courts, &c., the drainage of which is usually unsatisfactory. When making an examination of a well very careful attention should be paid to its construction and state of repair. The position of all drains in the vicinity, both surface and sub-soil, should be noted, and also the position of cesspools, sheep-dipping tanks, manure pits and the like. The carcases of animals are sometimes buried without due consideration being given to the possibility of subsequent pollution of the water draining into wells. Should a buried carcase be found to be the cause of contamination it is necessary to remember that permission to exhume and remove it has to be obtained from the Ministry of Agriculture and Fisheries, see Animals (Transit and General) Order, 1912, and Horses (Importation and Transit) Order, 1913. The extent of the ground surrounding a well that should be examined depends chiefly on the nature of the sub-soil, and on the depth of the well.

The Collection of Samples.—Many veterinary surgeons are called upon from time to time to collect samples of water for analysis. An improperly taken sample is useless, and may give quite erroneous results when subjected to analysis.

As the examination of a water supply is often done when a claim for alleged damage is contemplated, the greatest care is necessary when taking the sample to see that there is no extraneous contamination or other possible source of error.

The following directions are, in the main, abstracted by permission from Dr. Thresh's *Examination of Waters and Water Supplies.* The water should be collected in white glass bottles having well-fitted glass stoppers. A Winchester quart, holding about half a gallon, is convenient and easily obtained. Dark coloured bottles are to be avoided. When possible, bottles should be obtained from the laboratory making the test, as they are sent out chemically clean and all that is necessary is to remove the stopper and fill the bottle with the water. If bottles are not supplied by the chemist, care should be taken to choose clean ones, which should be well washed out, rinsed with acid, and then washed repeatedly with clean water. The stoppers must be cleaned in the same manner and then placed in the bottles. When filling a bottle with the water to be tested the stopper should be held in the hand and not laid on the ground. The bottle should be filled with the water and emptied three or four times. At the final filling a space should be left at the top, otherwise, if the bottle is quite filled, the neck is liable to crack

with any increase of temperature, while a decrease of temperature causes the stopper to become so firmly fixed that it cannot be removed without fracturing the neck. No jug or funnel should be used in filling the bottle and care must be taken when the water is run in that it does not flow over the hand.

In taking a sample from a pump or tap, some of the water should be allowed to run to waste before filling the bottle, unless the object of the intended analysis is to test the action of the water on the service pipes, as, for instance, for lead solvency, in which case the water should be left standing in the pipes all night and the first water drawn off in the morning taken for examination.

When collecting a sample from a stream, lake, spring or well direct, the stopper should be inserted and the whole bottle sunk well under the water, the stopper removed and the bottle filled. This prevents the inclusion of surface water. When taking a sample from springs and shallow streams, it is often necessary to excavate a cavity sufficiently deep to hold the bottle and the hand; then time must be allowed for settlement to occur before filling the bottle. When a bacteriological examination has to be undertaken, all risk of contamination should be carefully avoided. The bottles must be sterile and should have a capacity of 250 to 500 c.c., though a litre may be required.

The stoppers of bottles should be covered with wash-leather or clean linen, and must be sealed. A label should be affixed giving the source, date and time of sampling, and the name of the sampler. Full details concerning the water should be sent with the sample. These include a statement as to the kind of analysis required, *i.e.*, chemical or bacteriological, or both; the reasons for wishing an analysis; details as to the source of the supply, and any information pertaining thereto that may be of value to the analyst. The proximity of drains, cesspools, &c., if known, should be stated.

When the sample has been taken it should be transmitted to the chemist with as little delay as possible.

Physical Examination of Water. — This includes the general appearance of the water, its colour and turbidity, odour, taste and, of lesser importance, temperature.

Colour.—Take two glass tubes two feet in length having flat bottoms; place them on a white sheet of paper in a good light and into one pour the water to be tested and into the other the same quantity of distilled water. Special tintometers are used by water analysts by means of which can be recorded the finer shades of colouration. The water is examined vertically. A two-foot column of pure water has a "pale sky-blue tint." A yellowish

colour indicates the presence of organic matter. Peat imparts a red-brown colour, iron a reddish tint. Absence of any colour does not imply that the water is necessarily pure. If there is much turbidity the water should be filtered prior to the test being made, and this should be done in every case where the tintometer is used.

Turbidity.—The water should be examined in a white glass flask and compared with distilled water as described for colour detection. The following descriptions are applicable :—" brilliant," " bright," " clear," " dull," " slightly opalescent," " markedly opalescent," and " turbid " (Thresh). Estimation of the amount of suspended matter is sometimes a matter of importance, and for this any of the standard works on Water Analysis should be consulted.

Turbidity in water supplied for potable purposes is always to be regarded with suspicion, as it indicates contamination by surface water. Turbidity following soon after rain is especially objectionable.

Odour.—Warm a sample of the water in a flask, cork and shake well. Remove the cork and immediately smell. Note the character of the odour, if any. Descriptive terms are not easy of application as a number of individuals rarely have the same perception of smell. The following have been suggested :—Vegetable, aromatic, grassy, fishy, earthy, mouldy, musty, disagreeable, peaty, and sweetish (Thresh).

Pure water should have no smell. There are, however, two exceptions, peaty water nearly always has a slight odour, and certain waters contain sulphuretted hydrogen. Decomposing water-fauna and flora in service mains are not infrequently the cause of " smelly " water.

Taste.—It is not often that water to be analysed and examined as to its suitability for drinking purposes is tasted. This may, however, be necessary if complaints as to the water having a peculiar taste are put forward. The senses of taste and smell are often confused. Rain water has a flat insipid taste. Soft waters taste " soft." Ferruginous waters taste of ink. Waters containing much sodium chloride have a brackish taste. Peaty water has a peculiar taste of its own. The water from newly laid mains, especially if these have been laid with pipes the coating of which has not been properly dried, have a tarry flavour. Water treated with bleaching powder tastes of chlorine if the available chlorine used in the water exceeds three or four parts per million. If well aerated after treatment the taste is removed. Hard waters and those containing nitrates and carbonic acid, possibly dangerous

waters, are much more palatable than soft water or those free from much gas in solution.

Microscopical Examination.—The microscopical examination of water is often of great diagnostic value. The suspended matter is given about twenty-four hours to become deposited at the bottom of a tube and the supernatant fluid is syphoned off. Portions of the sediment are then transferred to a slide and examined under a low power. Hollow ground slides are more suitable than flat slides. In the sediment may be found mineral matter, dead vegetable matter, dead animal matter, vegetable organisms and animal organisms in the living state. The identification of any substance in the deposit is a difficult matter even for the expert. The vegetable and animal organic life seems to possess illimitable forms, fascinating enough to study, but without profit to the average observer. Those who wish to pursue the biologic features of water should consult any of the well-known text-books on the subject. The identification of mineral matter may in part be effected by the aid of the microscope and completed by the use of chemical reagents. Sand appears as large angular masses; clay as round, smooth globules; chalk smooth, but of crystalline appearance. If chalk is suspected, a little dilute hydrochloric acid run under the cover-glass will settle the point, for, if it is chalk, it will dissolve with the evolution of gas. Oxide of iron shows as a reddish-brown amorphous mass which will turn blue if a drop of potassium ferrocyanide solution be run under the cover-slip.

Dead animal matter is more easily recognised than is the case with vegetable matter. Vegetable tissues should, however, always be looked for and, if possible, identified so as to trace their source of origin. Linen and cotton threads and portions of household vegetables point to the presence of house waste. Wool, hair, muscular fibres and starch granules strongly indicate contamination with sewage matter.

Bacteriological Examination.—The bacteriological examination of water may give some idea of its suitability for drinking purposes. Like other tests it is subject to the possibility of errors, and its usefulness, though of undoubted value under certain circumstances, is not without limits.

In general, the bacteriological examination of water is done for the purpose of estimating the total number of bacteria in a given volume, such as one cubic centimeter; to isolate and discover the kinds of bacteria that are most numerous and to search for specific pathogenic organisms.

All waters, except perhaps those derived from artesian wells,

contain bacteria. Waters from deep wells and certain springs contain very few bacteria, 100 or less per c.c., some less than 10 per c.c., but the majority of wholesome drinking waters contain many more than this. Enumeration of the number of bacteria in filtered waters forms a valuable and safe guide as to the efficiency of the filtration, and it is considered that if the number does not exceed 100 per c.c. the filtration is in every way satisfactory. The examination must be made immediately the water is drawn, as after the lapse of a few hours the bacteria multiply enormously. Water drawn from the main or from house taps does not necessarily contain as low a count as at the source of supply, that is, as it leaves the filter-beds.

As to the total number of bacteria that should be permitted in drinking water, irrespective of their nature, it is very questionable if any standard of value can be adopted, though 100 per c.c. has been suggested as the limit.

There is great variation in the bacterial content of unfiltered waters. An average well may contain anything from 100 to 2000 per c.c., while in what may be regarded as first-class waters from springs, deep wells and well-protected shallow wells sunk in suitable ground, the number should not be expected to exceed 1000 per c.c. Moorland streams are usually comparatively free from bacteria, but most of them contain more than good springs and well-constructed deep wells do. Wells in constant and regular use contain fewer bacteria than those in which the water lies stagnant for periods. Sewage may contain from six to twelve million bacteria per c.c.

Of the micro-organisms for which special search is made, there are bacilli of the *colon group, streptococci,* and *Bacillus enteriditis sporogenes.* When pathogenic organisms get into water in company with the *B. coli* and its allies they die out (owing to unsuitable environment) before the latter, so that the absence of *B. coli* is more or less definite evidence that pathogenic organisms are also absent. On the other hand *B. coli* has been found in considerable numbers in water of undoubted purity of origin and safe from accidental contamination. *B. coli* is found in crude sewage in numbers ranging from 100,000 per c.c. upwards.

The presence of *streptococci* in water is generally regarded as an indication of recent contamination with sewage as they soon die out in water; on this, however, opinions are divided. Dr. Thresh considers that their presence, *per se,* is of no significance, but if with colon bacilli there is reason for strongly presuming that there has been pollution with sewage or manurial matter, and that if the

B. enteriditis sporogenes is present, the evidence may be regarded as conclusive.

The search for specific pathogenic organisms in water is unsatisfactory. Though it is not impossible to isolate and detect them when special methods are adopted, the process is difficult and the result uncertain. A negative result of such an examination can never be regarded as conclusive.

Chemical Examination.—The chemical examination of water is carried out to detect pollution. It may be either *qualitative* or *quantitative.* A qualitative examination of water serves only to give an indication of the presence or absence of any particular substance, and if it is present in large or small a quantity. It does not tell the actual amount that is present, and is, therefore, of limited utility. While the veterinary practitioner or inspector will not be called upon to make analyses of suspected waters, it is necessary that a knowledge of the processes should be acquired in order to fully understand an analyst's report and to appreciate the significance of the findings. Such knowledge can only be obtained through systematic and practical study in a laboratory. Hereunder are given some of the qualitative tests with some remarks on the interpretation of the results of a chemical analysis. For further information the reader should consult appropriate works on the subject.

Reaction.—It is necessary to test the reaction of water owing to the action of acid waters on lead.

Lime (calcium).—The addition of ammonia and the powdered crystals of ammonium oxalate gives a white haze, turbidity, or precipitate according to the amount of calcium present. The presence of 8 parts of calcium per 100,000 or 5 · 6 grains per gallon gives a distinct turbidity.

Magnesium. — Add ammonium chloride, solution of sodium phosphate and an excess of ammonia. The crystals of ammonium-magnesium-phosphate are precipitated, and the precipitation is hastened if the solution is freely stirred.

Chlorides.—The addition of dilute nitric acid and a solution of silver nitrate gives a white haze, turbidity or precipitate of silver chloride according to the amount of chlorides present. One grain per gallon or 1 · 5 parts per 100,000 gives a decided haze, while 4 grains per gallon or 5 · 7 parts per 100,000 gives a marked turbidity.

Sulphates.—Dilute hydrochloric acid and a solution of barium chloride gives a white haze, turbidity or precipitate of barium sulphate according to the amount of sulphates present (the sulphates

are found as calcium and magnesium sulphates in hard waters). This test will detect 2 grains per gallon or 3 parts per 100,000, which amount will cause a haze to slowly appear.

Sulphides.—A few drops of dilute caustic soda followed by a few drops of a solution of nitro-prusside of soda gives a violet colour if only a trace of sulphuretted hydrogen is present.

Ammonia.—The addition of two or three drops of Nessler's solution gives a yellow or yellow-brown colour if there is only a trace of ammonia present.

Nitrites.—When a solution of zinc iodide starch and dilute sulphuric acid is added to water containing nitrites a blue colour appears. The rationale of this test is the liberation of nitrous acid from the nitrites by the addition of the sulphuric acid. The free nitrous acid liberates free iodine from the zinc iodide, which then turns the starch blue. The test is extremely delicate, and detects 1 part in 50 millions. A second test is the addition to the sample of metaphenylaminediamine and dilute sulphuric acid; a brown colour appears slowly in the presence of nitrites.

Nitrates.—Evaporate to dryness about 25 c.c. of the water, add 2 drops of sulphuric acid and a granule of brucine. A rose colour appears which later gives rainbow shades. This test detects 1 part in 1 million.

Another test is the addition of a few drops of a solution of diphenylamine in sulphuric acid and some strong sulphuric acid. This gives a blue colour in the presence of nitrates.

Phosphates.—Add some dilute nitric acid to the water then evaporate to dryness, heat the residue and redissolve it in dilute nitric acid and filter. To the filtrate add a double volume of strong warmed ammonium molybdate solution. If phosphates are present there will appear slowly ammonium-phospho-molybdate having a yellow colour.

Oxidisable Organic Matter.—Add to the sample N/100 solution of potassium permanganate, acidify with sulphuric acid and warm gently. The potassium permanganate gives a pink colour to the water, which disappears if there is oxidisable organic matter, slowly if it is of vegetable origin and more rapidly if animal matter.

Iron, Copper and Lead.—To detect and differentiate between these three metals proceed as follows:—Add ammonium sulphide to the sample, a black colouration results if any one of the three is present. Divide the treated sample into two parts. Into one part add dilute hydrochloric acid, if the colour disappears iron is present. If the colour does not go add to the second sample some potassium cyanide solution, if the colour disappears it is

copper, and if persistent it is lead. Then apply these confirmatory tests. For *Iron*—Acidify the water with nitric acid and concentrate by heat. Cool and add potassium sulphocyanide. If iron is present a blood red colour will result. For *Lead*—Concentrate the water and add chromate of potassium, the minutest trace of lead will give a faint yellow turbidity. For *Copper*—Concentrate the water, add some ammonium sulphide and then a solution of potassium cyanide; copper gives a mahogany colour.

Zinc.—Add some nitric acid, boil, concentrate and filter. To the filtrate add some potassium ferrocyanide. In proportion to the amount of zinc present there will be a white haze, turbidity or a precipitate. This detects the merest trace of zinc in water.

Arsenic.—Add to 1 litre of the water 1 gramme of pure sodium carbonate and evaporate to dryness. Dissolve the residue in 50 c.c. of distilled water, then add 1 c.c. of pure hydrochloric acid and 2 pieces of copper foil. Then boil. If arsenic is present there will appear a steel-grey deposit on the copper.

Notes.—When making comparisons between samples of water to which reagents have been added and one without reagents, always use columns of water of equal length in similar test tubes. When making observations of reactions, where the result is a white haze or turbidity, look down through the test tube against a black ground; where the result is a darkened discoloration, or a yellow, blue, or pink colour, look against a white ground.

Hardness.—The total hardness of water may be determined as follows:—Run 100 c.c. of the water into a 200 c.c. bottle, add standardised soap solution (1 c.c. of which will produce a lasting lather in water free from magnesium and calcium salts) 1 c.c. at a time. When sufficient has been added to obtain a lather that will persist for 5 minutes when the bottle has been laid flat, the reaction is at an end. The bottle should be vigorously shaken after each addition of the soap solution. As 1 c.c. is required to produce a lather in water free from calcium or magnesium salts this amount must be deducted when making the calculation. Each c.c. of the soap solution required to produce a lasting lather is equivalent to 1 degree of hardness (1 part per 100,000). Thus, supposing 10 c.c. are required to obtain a lather, the water is of 9 degrees hardness. If the water is very hard it must be diluted with distilled water before the test is made, and allowance made accordingly.

To determine temporary hardness, boil the water and filter and make up the amount lost by evaporation with distilled water. Then make the test. The result will give the permanent hardness, and the temporary hardness is found by difference. Boiling does not

throw down all the calcium and magnesium salts, so that this method is not strictly correct.

Interpretation of the Results of Analysis.—The interpretation of the results obtained from an examination of a water is most difficult, and can only be done correctly by a water analyst of considerable experience. Hereunder is given a brief résumé of the indications that lead to the formation of an opinion as to the fitness or otherwise of water for drinking purposes.

Appearance.—The absence of colour is no indication of purity. A yellow or green tint would lead one to suspect that the water is polluted, but confirmation of this should be sought in the chemical or bacteriological examination. Turbidity is always suspicious of surface water, and especially if this occurs after heavy rain.

Odour.—With the exception of peaty water and water containing sulphuretted hydrogen, water should have no smell. Absence of smell is no sign of purity.

Reaction.—Acid waters act on metals. This is of special importance where lead pipes are used.

Residue left on Evaporation.—A small amount of white residue which shows little or no change on ignition indicates a water free from organic impurity. If the residue has a brown tint and chars on ignition, the indication is that organic matter is present. If a disagreeable odour is given off when the residue is strongly heated to ignition, organic matter of animal origin is to be suspected. Waters containing much nitrates with organic matter may not char, while the residue of peaty water does char.

Chlorides.—Chlorides are found in all waters, chiefly as sodium chloride, with occasionally magnesium, potassium and calcium chloride. In practice the chlorine is estimated and either expressed as so many parts of chlorine per 100,000 or, on the assumption that all the chlorine is derived from sodium chloride (the remainder being so small), by multiplying the chlorine by 1·65 and stating it as grains of sodium chloride. Any amount of chlorine by itself has no hygienic significance except that much excess of salt would make it unsuitable for drinking or washing purposes. By itself it is no indication of pollution either past or recent, but if two wells sunk in the same district and penetrating similar strata yield waters differing markedly in chlorine content, then it may be assumed that the one with the high content is polluted with sewage or manurial matter, the chlorine being derived from the urine. Waters containing chlorine and nitrates in large quantity with much organic matter have almost certainly been polluted with organic matter of animal origin, and that at no distant

time. Salt may be found in sea-spray; it may enter a supply from the sea; it may be present in natural salt beds, and may have percolated the soil from top-dressing the land with salt.

Nitrates.—The nitrates themselves found in water are harmless. They may or may not be an indication of pollution. Rain water contains traces of nitrates which are formed in the air by electric action during thunderstorms. Nitrates are chiefly derived from animal organic matter by oxidation, the animal matter being sewage, manure or the buried carcases of animals. The nitrogen comes from the decomposition and splitting up of the animal protein; this becomes converted into nitric acid in the soil, and in turn unites with the soil carbonates to form nitrates. The sequence is as follows:—Protein, Ammonia, Nitrites, Nitrates.

Nitrifying organisms in the soil bring about the formation of nitrates. In deep well waters from chalk, nitrates may be plentiful owing to the nitrification and filtration that has occurred in its passage through the soil. But Rideal points out that filtration and nitrification may be so rapid that pathogenic organisms may still be present in the water though nitrates have been formed. In general, the presence of nitrates indicates a previous pollution, and that the water has undergone purification.

As to the limit of nitric nitrogen allowed in drinking water, this depends a good deal on other factors. Probably 0·5 parts per 100,000 may be taken as the maximum that should be allowed. No arbitrary standard can, however, be laid down.

Nitrites.—These may be formed by the reduction of nitrates in the soil, with this exception, their presence always points to recent contamination of the water with animal organic matter, and that it is undergoing oxidation or purification. A reducing metal, lead, zinc or iron, in the water will bring about reduction of the nitrates to nitrites, and absence of either of these when nitrites are present means that they are of animal origin.

Ammonia.—Ammonia is estimated as Free and as Albuminoid Ammonia. Nearly all waters contain ammonia but, with the exception of rain-water, water containing reducing metals which reduce the nitrates, and some deep-well waters, the presence of ammonia in anything above a trace is strongly suspicious of very recent pollution with sewage or other animal matter. Absence of ammonia, on the other hand, is no indication that the water is pure. Water containing nitrates passing through ferruginous sands has the nitrates reduced to ammonia in the same way as the iron of iron pipes reduces it. The presence of ammonia in such a circumstance is not, therefore, to be regarded as evidence of

sewage pollution. A knowledge of the source of supply is necessary in this case as with all other deductions concerning possible pollution. As to the limit of permissible ammonia this, as with other impurities, depends upon the other constituents and other factors which the analyst takes into consideration before giving his final decision. "It is often difficult, if not impossible, to judge of the character of a water by the amount of the ammonia which it contains, but wherever the amount exceeds 0·004 per 100,000 an endeavour should be made to ascertain its origin."

Organic Matter.—The amount of oxidisable organic matter in water helps, when taken collectively with the other analytical results, to determine the condition as regards contamination.

As the test applied is to note the amount of oxygen the water will take up from a substance that readily parts with its oxygen (permanganate of potassium), the results are expressed in so many parts of oxygen absorbed per 100,000 of water. Sometimes iron and nitrites are found to absorb oxygen from the permanganate. The oxidisable material in water may be of vegetable or animal origin, and the test applied does not distinguish the one from the other. Upland surface waters may contain a very considerable quantity of vegetable matter, and peaty waters especially may absorb a large amount of oxygen.

Standardisation is difficult. The table of standards here given is that of Sir E. Frankland and Dr. Tidy.*

Amount of Oxygen absorbed in 100,000 Parts of Water.

	Upland Surface Water.	Other Waters.
Waters of great organic purity	Not more than .10	Not more than .05
Waters of medium purity	" " " .30	" " " .15
Waters of doubtful purity	" " " .40	" " " .20
Impure water	More than .40	More than .20

* *The Examination of Waters and Water Supplies*, J. C. Thresh, 1913.

SECTION II.

METEOROLOGY.

METEOROLOGY has been defined as the "Science of the Weather and Climate," and thus includes the varied phenomena taking place in the atmosphere. In what follows will be found a description of the chief phenomena investigated and the means by which this investigation is carried out.

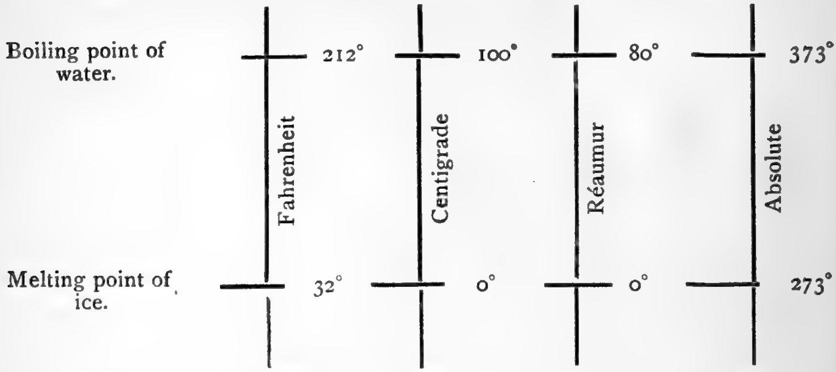
TEMPERATURE is measured by means of a thermometer. The common type of thermometer is one in which mercury or alcohol is used as the thermometric substance, the measurement depending upon the thermal expansion of the substance. Alcohol thermometers can be used for recording lower temperatures than mercury ones, since the freezing point of alcohol is -130° C, while that of mercury is -39° C.

The thermometer is graduated and divided into degrees. There are two fixed points, viz., the temperature of steam rising from water boiling under standard pressure (760 mm. of mercury) and the temperature of melting ice. These points are indicated respectively by 212° and 32° on the Fahrenheit scale, the interval between them being divided into 180 equal parts or degrees. The corresponding points and interval in the case of the Centigrade scale are 100° and 0° with 100 degrees between, while for the Réaumur scale they are 80° and 0° with 80 degrees between. To convert from one scale to another :—if F, C, R represent the *same* temperature on Fahrenheit, Centigrade and Réaumur scales respectively, then the following relation can be used for the required conversion :—$\frac{F-32}{180}=\frac{C}{100}=\frac{R}{80}$; *e.g.*, to convert 10°C to Fahrenheit,

$$\frac{F-32}{180}=\frac{C}{100}=\frac{10}{100} \therefore F-32=18 \ . \ F=50^\circ \text{ Fahrenheit.}$$

There is another scale called the Absolute Scale, the zero of which is -273° C, so that if A° be the absolute temperature and C° the Centigrade, the relation is $A^\circ = C^\circ + 273$.

Diagrammatically the various scales may be represented thus :—



Maximum and Minimum Thermometers.—The *maximum* thermometer automatically gives a record of the highest temperature reached during an interval of time. The thermometric substance is usually mercury, and the thermometer is hung horizontally. One method of recording is by means of a constriction near the bulb. When a fall of temperature occurs the mercury thread is broken at the constricted portion of the tube and reading of the end of the thread farthest from the bulb gives the maximum temperature. Another form utilises an air bubble in the mercury thread, this bubble performing the same function as the constriction in the pattern described above. The *minimum* thermometer gives, as its name implies, the lowest temperature reached during an interval of time. The thermometric substance is alcohol or some such spirit, and with a fall of temperature the liquid contracts and draws with it a small index *immersed* in the liquid. A later expansion does not move the index as the liquid flows past it.

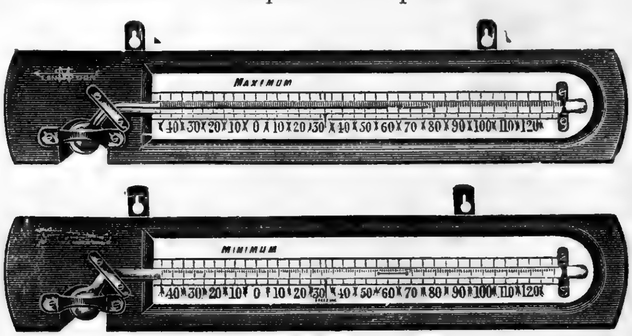


FIG. 2.—Maximum and Minimum Thermometers.

Thermographs are self-registering thermometers giving variation of temperature with time.

HUMIDITY refers to the amount of aqueous vapour present in the atmosphere. The existence of vapour pressure can be shown

by introducing a little water into the Torricellian vacuum of a barometer tube. The aqueous vapour which is formed drives the mercury down by an amount which measures the aqueous vapour pressure. If sufficient liquid is present the vapour pressure reaches a maximum, called the *saturation pressure,* for a given temperature and increases with the temperature. There is always a certain amount of aqueous vapour present in the atmosphere, and it becomes of importance to measure the amount present at any given time.

By *hygrometry* is meant the study of the amount of aqueous vapour present at any time in the atmosphere, and instruments which enable this to be carried out are termed *hygrometers.*

By *Relative Humidity* or *Hygrometric State of the Atmosphere* is meant the ratio of the actual mass of water vapour present in any volume of the air at any temperature to that mass which would be present if that volume of air were saturated at that temperature. The *Dew Point* is that temperature at which the water vapour then present in the atmosphere would be sufficient to saturate it.

Since the vapour pressure approximately follows Boyle's Law we see that :—

$$\text{Relative Humidity} = \frac{\text{Saturated vapour pressure at dew point}}{\text{Saturated vapour pressure at air temperature}},$$

and it is usually expressed as a percentage.

The commonest type of hygrometer is that known as the *Dry and Wet Bulb.* It consists of two thermometers, one, the dry bulb, being simply an ordinary thermometer while the wet bulb has muslin wound round the bulb; this muslin is attached to threads of cotton which dip into a small vessel of water and is thus kept "wet." The combination of thermometers is also called the *Psychrometer.* The wet bulb temperature is generally less than that given by the dry bulb for evaporation is constantly going on, unless the surrounding air is saturated with water vapour, and part of the heat of vaporisation (latent heat) is taken from the thermometer in question, thus lowering its temperature.

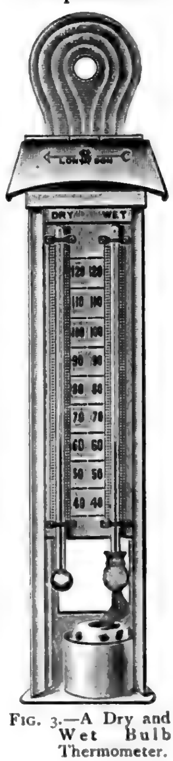


FIG. 3.—A Dry and Wet Bulb Thermometer.

The readings of the temperatures of the two thermometers together with a suitable set of tables will enable the dew point, aqueous vapour pressure and relative humidity to be determined, for if the difference between the temperatures of the dry and wet bulb or "depression of the wet bulb" be

multiplied by Glaisher's factor (f), the dew point can be determined by the formula:—

$$\frac{\text{Temperature of air—dew point temperature}}{\text{Temperature of dry bulb—temperature of wet bulb}} = f$$

and from the temperature of the air and the dew point the relative humidity can be calculated by means of a table of standard vapour pressures.

The following tables give Glaisher's factors for different temperatures of the dry bulb and tension of aqueous vapour in inches of mercury for different temperatures:—

GLAISHER'S FACTORS.

Reading of Dry Bulb Therm. °F.	Factor.	Reading of Dry Bulb Therm. °F.	Factor.	Reading of Dry Bulb Therm. °F.	Factor.	Reading of Dry Bulb Therm. °F.	Factor.
10	8.78	33	3.01	56	1.94	79	1.69
11	8.78	34	2.77	57	1.92	80	1.68
12	8.78	35	2.60	58	1.90	81	1.68
13	8.77	36	2.50	59	1.89	82	1.67
14	8.76	37	2.42	60	1.88	83	1.67
15	8.75	38	2.36	61	1.87	84	1.66
16	8.70	39	2.32	62	1.86	85	1.65
17	8.62	40	2.29	63	1.85	86	1.65
18	8.50	41	2.26	64	1.83	87	1.64
19	8.34	42	2.23	65	1.82	88	1.64
20	8.14	43	2.20	66	1.81	89	1.63
21	7.88	44	2.18	67	1.80	90	1.63
22	7.60	45	2.16	68	1.79	91	1.62
23	7.28	46	2.14	69	1.78	92	1.62
24	6.92	47	2.12	70	1.77	93	1.61
25	6.53	48	2.10	71	1.76	94	1.60
26	6.08	49	2.08	72	1.75	95	1.60
27	5.61	50	2.06	73	1.74	96	1.59
28	5.12	51	2.04	74	1.73	97	1.59
29	4.63	52	2.02	75	1.72	98	1.58
30	4.15	53	2.00	76	1.71	99	1.58
31	3.60	54	1.98	77	1.70	100	1.57
32	3.32	55	1.96	78	1.69		

TABLE OF SATURATED VAPOUR PRESSURES.

Temp., F.	Tension in ins. of Mercury.	Temp., F.	Tension in ins. of Mercury.	Temp., F.	Tension in ins. of Mercury.	Temp., F.	Tension in ins. of Mercury.
0	0.044	24	0.129	48	0.335	72	0.785
1	0.046	25	0.135	49	0.348	73	0.812
2	0.048	26	0.141	50	0.361	74	0.840
3	0.050	27	0.147	51	0.374	75	0.868
4	0.052	28	0.153	52	0.388	76	0.897
5	0.054	29	0.160	53	0.403	77	0.927
6	0.057	30	0.167	54	0.418	78	0.958
7	0.060	31	0.174	55	0.433	79	0.990
8	0.062	32	0.181	56	0.449	80	1.023
9	0.065	33	0.188	57	0.465	81	1.057
10	0.068	34	0.196	58	0.482	82	1.092
11	0.071	35	0.204	59	0.500	83	1.128
12	0.074	36	0.212	60	0.518	84	1.165
13	0.078	37	0.220	61	0.537	85	1.203
14	0.082	38	0.229	62	0.556	86	1.242
15	0.086	39	0.238	63	0.576	87	1.282
16	0.090	40	0.247	64	0.596	88	1.323
17	0.094	41	0.257	65	0.617	89	1.366
18	0.098	42	0.267	66	0.639	90	1.410
19	0.103	43	0.277	67	0.661	91	1.455
20	0.108	44	0.288	68	0.684	92	1.501
21	0.113	45	0.299	69	0.708	93	1.548
22	0.118	46	0.311	70	0.733	94	1.596
23	0.123	47	0.323	71	0.759	95	1.646

Example of the method of determining the relative humidity: *e.g.*, If the dry bulb thermometer records a temperature of 51° F and the wet bulb 49° F, what is the relative humidity? It is first necessary to find the dew point. On referring to the table of Glaisher's factors it will be found that the value of Glaisher's factor for a dry bulb reading of 51° F is 2·04. If the difference between the temperatures of the dry and wet bulb be multiplied by this factor and the result subtracted from the dry bulb temperature, the result will be the dew point, *i.e.*, $51 - \{(51-49) \times 2.04\} = 46{\cdot}9°$ F.

The temperature of the dew point is therefore 46·9° F. From the table of saturated vapour pressures it is found that if the air at a temperature of 51° F were saturated with moisture, the tension of aqueous vapour would be 0·374 inch of mercury; the tension of the vapour actually present is the maximum tension corresponding to the dew point (46·9° F), which is 0·322. Therefore the relative humidity expressed as a percentage, is:— $\frac{0.322}{0.374} \times 100 = 86.2$.

Precipitation. — *Rain* — As has been already stated (see Humidity) the atmosphere can only contain a certain maximum amount of water vapour and, on a lowering of temperature taking place, condensation occurs and the formation of large droplets is

accompanied by a fall of rain. A *rain gauge* enables the rainfall to be measured.

A gauge of the Meteorological Office type consists of a funnel of 5 or 8 inches diameter and a graduated glass vessel, which thus enables the rainfall to be determined. There is also another type known as the Snowden rain gauge.

FIG. 4.—A Rain Gauge.

An inch of rain falling on one square yard is equal to 4·67 gallons, and 1 inch on 1 acre to 110 tons. The average rainfall for England and Wales is approximately 37 inches annually, for Scotland 43 and Ireland 39 inches. On the west coast the fall is greater than on the east. One inch a day is regarded as a heavy fall, while 4 inches on one day is exceptionally heavy.

Dew has already been referred to under Dew Point, and consists of drops of moisture deposited on cold surfaces. Blades of grass may also have dew formed on them by water rising through the vessels of the leaf.

Fog, Mist, Haze.—In some cases these have been taken to be almost synonymous terms. The general feature is that the atmosphere is rendered partially obscure on account of the presence of drops of water or solid particles.

According to the *Meteorological Glossary*, a *fog* generally implies that movement is rendered difficult on account of the obscurity produced. There is a cloud present at or close to the surface level which may contain smoke and dust particles, etc., while a *mist* consists of a cloud at surface level containing water droplets and a *haze* may arise from impurities such as dust or smoke particles or variations in density of portions of the atmosphere.

Hail refers to the falling of frozen water. In hard or true hail the hailstones are hard and may in cases be large; in soft hail the product is soft and has a consistency resembling hardened snow. It was proposed at a conference at Vienna to define hail as " the precipitation of frozen water in which the stones attain such a magnitude that they may be expected to do damage to agricultural products."

Snow consists of a fall of " feathery ice crystals," while a fall of " rain and snow together or snow partly melted " is termed *sleet.*

PRESSURE.—Instruments for determining the pressure of the atmosphere are known as *Barometers.*

That the atmosphere exerts pressure can be shown by taking a glass tube of a length of about 32 inches, closed at one end and completely filled with mercury; when the open end is opened vertically over a reservoir of mercury, it will be found that the mercury in the tube settles at a level of about 30 inches above the free surface of the liquid in the reservoir. Thus the 30 inches of mercury are supported by the pressure of the atmosphere and afford a measure of the atmospheric pressure at that instant (Torricelli's experiment).

Forms of mercury barometers are adaptations of the above.

The Fortin Barometer consists of a glass tube of about 80 cm. length, closed at the top end and dipping into a vessel of mercury. There is a fixed measuring scale, and the mercury in the vessel can be adjusted to the zero of this scale by a screw which alters the level of the mercury in the vessel till it coincides with the zero. This is done by raising or lowering the bottom of the vessel, which consists of a piece of leather. This adjustment must be made before a reading is taken, and, when it has been carried out, the level of the upper surface of the mercury can be read by means of the scale and vernier attached.

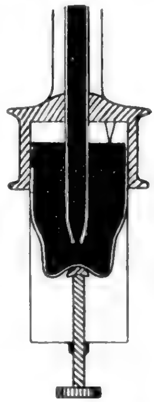


FIG. 5.—Fortin's Barometer.

The Kew Pattern Standard Barometer has the diameter of the tube contracted along a great part of its length to obviate the disturbing effects of oscillation or " pumping." It is thus admirably suitable as a marine barometer. Moreover to save periodical adjustment of the level of the mercury in the reservoir it has a scale of " shortened " inches, which takes account of the relative capacities of tube and reservoir.

The Aneroid Barometer does not contain liquid but consists of a metal vessel, usually corrugated in form, from which the air has been partially removed. The pressure of the atmosphere causes the vessel to tend to collapse, but a spring, attached to it, obviates this. By means of a suitable motion, consisting of a system of levers, the changes in the barometric pressure can be recorded on a scale by a pointer.

A Barograph is a self-recording barometer, the changes in the barometric pressure with time being shown, in general, on a sheet of paper attached to a revolving drum. The usual form of barometer adapted as self-recording is the aneroid.

The units by means of which barometric pressure is indicated

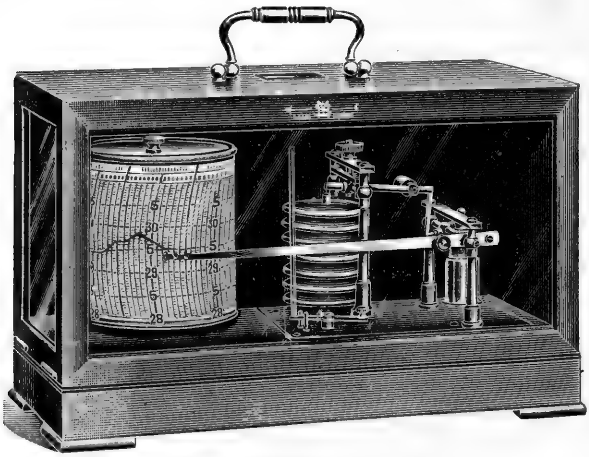


FIG. 6.—A Barograph.

may be inches or centimetres of mercury or millibars, the pressure unit on the C.G.S. system in use at the Meteorological Office. (1 millibar = 1000 dynes per sq. cm. = ·02953 mercury inch and one-tenth of a millibar = ·003 mercury inch and is the limit of accuracy of a barometer under ordinary circumstances.)

Barometric readings require to be corrected for temperature and latitude, and, in order that readings may be compared one with another, these should be corrected for altitude above sea level and thus reduced to readings at the same level, viz., sea level.

The term *isobar* refers to a line drawn through places which have the same barometric reading at a given time. Thus, by means of a series of isobars, regions of high and low pressures can be identified, and valuable information can be derived by a study of such a map.

Low pressure regions are termed Cyclones or Depressions or Lows, and those of high pressure are Anticyclones or Highs. In anticyclones the weather, generally speaking, is usually fine, while in cyclones it is the reverse.

Eddy motion is also a factor of considerable moment in connection with the mixing of air layers and production of cloud.

CLOUDS.—Clouds are characterised as cloud sheets and cloud heaps. The general distinction as regards appearance is whether they form an extended horizontal sheet or not. As far as the mode

of formation is concerned cloud sheets may be due to a layer of damp air becoming sufficiently cooled by expansion, owing to a fall of pressure, to form cloud, while cloud heaps are due to air rising and on expansion becoming cooled so as to form a cloud (*Meteorological Glossary*).

Clouds are identified as being connected with different heights at which they exist. It will be sufficient to describe the principal cloud forms, though it may be noted that the International Meteorological Committee have drawn out a list of definitions and descrip-

FIG. 7.—Campbell-Stokes' Sunshine Recorder.

tions of cloud forms which includes all the intermediate forms of clouds.

Howard's original classification described three forms:—

Cirrus (Mares' tails), at a high altitude, feathery and white, consists of crystals of ice.

Cumulus, rounded in appearance at the top, base usually flat.

Stratus, formed in layers, foglike in appearance. To these may be added *Nimbus,* of no definite shape, the source usually of rain and snow.

SUNSHINE.—The Campbell-Stokes' sunshine recorder focusses the rays of the sun by means of a glass sphere so that they fall on

a card and leave a record. This card is divided into hours, and is bent into a spherical shape.

WIND.—Wind is caused by the movement of the air, and this movement takes place on account of the sun warming different regions of the earth to a different degree and producing differences of pressure.

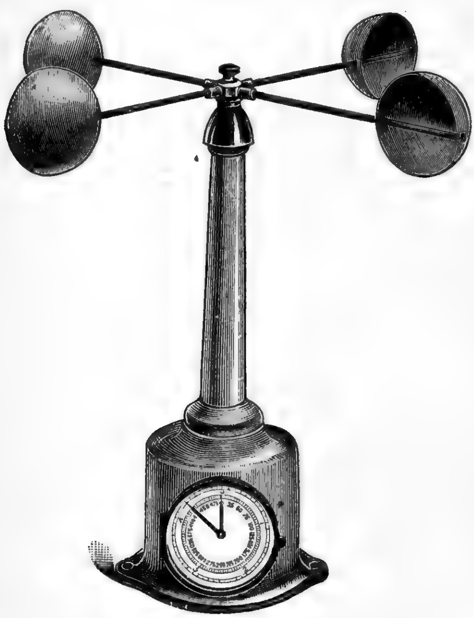


FIG. 8.—Robinson's Anemometer.

The familiar windvane gives the direction from which the wind comes. It should be placed on a high point, move easily and be unaffected by stray local currents.

The speed or force of the wind is determined by an *anemometer*, of which there are three general types which have been termed the "windmill," "pressure tube" and "pressure plate." Details of these will be found in the *Observer's Handbook.*

The scheme adopted in 1805 by Admiral Beaufort of estimating wind force by numbers from 0 to 12 is known as the Beaufort Scale. The Meteorological Office has issued a table giving a comparison between the Beaufort Scale numbers and their velocity-equivalents. The following table which is taken from the *Observer's Handbook* also gives "descriptions of the wind force intended to guide the judgment of observers."*

*G. C. Simpson, F.R.S., Director of the Meteorological Office, has drawn up a specification of the Beaufort Scale for coast use. M.O. Publication 180. 1906.

Beaufort Number.	Explanatory Title.	Specification of Beaufort Scale for use on Land, based on Observations made at Land Stations.	Limits of Speed at 33 ft. in the open. Miles per Hour.
0	Calm, . .	Calm: Smoke rises vertically.	Less than 1
1	Light air, . .	Direction of wind shown by smoke drift but not by wind vanes.	1–3
2	Slight breeze, .	Wind felt on face; leaves rustle; ordinary vane moved by wind.	4–7
3	Gentle breeze, .	Leaves and small twigs in constant motion; wind extends light flag.	8–12
4	Moderate breeze,	Raises dust and loose paper; small branches are moved.	13–18
5	Fresh breeze, .	Small trees in leaf begin to sway; crested wavelets form on inland waters.	19–24
6	Strong breeze, .	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.	25–31
7	High wind, .	Whole trees in motion; inconvenience felt when walking against wind.	32–38
8	Gale, . . .	Breaks twigs off trees; generally impedes progress.	39–46
9	Strong gale, .	Slight structural damage occurs (chimney pots and slates removed).	47–54
10	Whole gale, .	Seldom experienced inland; trees uprooted; considerable structural damage occurs.	55–63
11	Storm, . .	Very rarely experienced; accompanied by wide-spread damage.	64–75
12	Hurricane, . .	. . . .	Above 75

Land and Sea Breezes.—Land during daytime is heated to a higher temperature than the sea, consequently the hot air over the land rises and the cooler air from the sea flows in to take its place—a *sea breeze.* During night-time the land cools more quickly than the sea so that the above process again takes place but with the direction of the breeze reversed, the hotter air rising from the sea and the cooler air from the land flowing to take its place—a *land breeze.*

Trade Winds.—In the Atlantic Ocean we have the north-east and south-east trades north and south of the equator respectively.

The usual explanation given as to how they arise is due to Halley, and consists in considering the effect of hot air rising in the equatorial region and cold air from the north or south respectively flowing in to take its place, while the directions of flow are modified by the rotation of the earth as was first pointed out by Hadley. From the general study of air currents made by the staff of the Meteorological Office, it is concluded "that the great arterial currents are really part of the general circulation of the atmosphere,

governed by the distribution of pressure" (*Meteorological Glossary*).

Monsoons.—These are chiefly manifest in India and China. Their direction is reversed with the seasons; in summer they are south-west and in winter north-east. They are of great importance from an economic and climatic point of view in the regions over which they blow.

Atmospheric Electricity and Lightning.—Franklin by flying a kite with an iron point was able to get large sparks of electricity when the string was sufficiently wet to become conducting. He thus showed that there exists electricity in the atmosphere. During a thunderstorm the effects may be very great and we may have a discharge between two clouds or between a cloud and the earth or an earth-connected body.

There exists normally in the atmosphere a difference of potential between two points at different vertical distances apart, and the upper point is usually at the higher potential.

In certain regions, however, and under abnormal conditions in any particular region the higher point may be at the lower potential.

In Edinburgh the average value of the potential gradient during 1912 was 167 volts per metre and the direction is usually reversed during bad weather, *e.g.*, a rainstorm, as is the case at most stations. This gradient has diurnal and annual variations.

A lightning conductor, which acts as a protection for a building, consists of a metal point situated above the building and connected by a metallic conductor to a "good earth." It is better to have all the exposed points protected by rods which are connected to several "good earths." The ideal system is to have the building covered with a wire mesh-work electrically connected to earth.

Exposed country is a more dangerous place to be in than a town during a thunderstorm. A tree by itself is more likely to be struck than any given one forming part of a wood, and trees differ, according to kind, in the frequency with which they are struck. Oak trees are very dangerous. The order for a number of different trees as regards danger (beginning with the most dangerous) is oak, Scotch pine, spruce, beech.

Weather Forecast.—If the values of the various meteorological phenomena from different regions at a given time are plotted on a map of these regions then it is possible to forecast the weather. This map is known as a "weather map" or "synoptic chart," and the Meteorological Office in general forecasts for the future 24 hours, whilst general conditions of the weather may be given for a longer period. The data are collected by a central office and

are obtained by telephone, telegraph, wireless, &c., and comprise the barometric height, the wind force and direction, temperature, state of the weather as regards precipitation, cloud, &c. A study of the isobars as regards distribution, shape and steepness is of primary importance from the point of view of forecasting.

Climate. — By climate of any region is meant the kind of weather experienced in that region. Clearly this statement will be the result of a large number of observations extending over a considerable period. Regions differ with regard to climate on account of various factors, *e.g.*, proximity to the sea, geographical latitude, configuration, altitude, soil and vegetation, &c.

The main meteorological phenomena on which the climate will depend have already been described and include temperature, precipitation in all its forms, winds, &c.

Climates may be classified according as they depend on temperature and humidity :—cold or arctic, temperate, hot or tropical, insular and continental.

Further information on "Meteorology" will be found in the *Observers' Handbook* and *Meteorological Glossary* issued by the Meteorological Office.

SECTION III.

SANITATION.

The hygienic disposal of excreta and other solid and liquid waste material is a matter of great importance, as the health of both man and animals is dependent to a very large extent on the efficiency of the method adopted. A system of pipes for the removal of refuse, either liquid or rendered more or less liquid by the addition of water, from a habitation constitutes a drainage system. As liquids which have to be conveyed away are for the most part foul, open channels are unsuitable and pipes of some form must be used. A drain is a pipe or channel used for the conveyance of liquids. The object of a drainage system is to convey the refuse from the various points of origin to the public sewer or other point of outfall as rapidly as possible and in such manner as to cause no inconvenience or nuisance.

In the case of a house it is usual to classify the liquid refuse into three classes:—(1) Soil; the discharge from w.cs., urinals and slop sinks. (2) Waste: the discharge from sinks, lavatory basins, baths and wash tubs. (3) Rain water. A drain is a soil drain if it takes the discharge from a soil fitting, no matter how much waste and rain water it also conveys. A rain water drain conveys nothing but rain water. In the case of animal habitations there will only be two classes, soil and rain water.

A drainage system should be simple and as free as possible from complicated traps and other fittings. The number of pipes in a system must be reduced to the necessary minimum. Pipes should be laid in straight lines so far as possible, and access should be provided at all the principal changes of direction. Pipes must be of such capacity and laid at such a gradient as will render them self-cleansing. Special attention must be paid to junctions. The entire system must be thoroughly ventilated, that is, air inlets and outlets must be so arranged that fresh air can find its way to every part of the system and so ensure that at any time the pressure inside at any point is atmospheric.

Drain Pipes.—Drain pipes must possess strength to withstand the pressure of the superimposed soil and the weight and jar of traffic. Strength is also necessary to resist the internal pressure of gases, though this should not be great in well-ventilated drains.

Internal pressure from the accumulation of a large body of water in any length of piping may be considerable in the case of blockage, and might be sufficient to burst fireclay pipes, especially if these contain faults. Ground subsidence may put a great strain on pipes, but the likelihood of this occurring depends naturally upon the nature of the soil. Drain pipes must have a smooth internal face so that the free passage of waste matter is not hindered. A rough internal surface checks the even flow and facilitates the lodgment of solid particles, which then hold back still more with disastrous results. The internal surface must also resist the corrosion of liquids or gases. Pipes must be durable, be able to withstand alternating temperatures, the action of chemicals and the friction of sand and other solid particles. Absolute impermeability to gases and water is an essential feature without which any drain pipe is not only useless but extremely dangerous, as otherwise the surrounding soil would soon become permeated with sewage and sewer gases, the presence of which is only detected when disease appears and damage is done which might, and should, have been averted. The shape of drain pipes must be such as to offer the least possible friction to the passing fluids, therefore the old-fashioned rectangular-built drains have given place to round pipes.

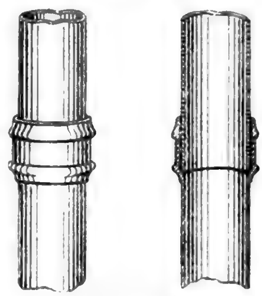


FIG. 9.—Rain Water Down Pipe. Putty Joint.

If the quality of the pipe is of prime importance, the jointing is no less so; therefore pipes must be so made that perfect jointing can be effected. For this purpose one end of a pipe is fitted with a collar into which fits the spigot end. The joint is made with material which depends on the nature of the pipe. The collar or faucet is at the proximal or inflow end and the spigot fits into the collar of the succeeding pipe.

Drain pipes are made of stone-ware, fireclay or of cast-iron. Stone-ware pipes during the firing process become vitrified throughout the whole thickness of the wall of the pipe and consequently are practically tight; they are nevertheless salt glazed. On the other hand fireclay pipes are made of a much more refractory material; they are never near the vitrifying point during the firing process and would be fairly porous. To overcome this they are treated inside before firing with a coat of slip glaze which practically forms a thin coat of glass. They are also salt glazed during firing. Fireclay pipes are mostly used in Scotland as this country possesses no stone-ware deposits. They are made thicker than stone-ware pipes. The thickness of a fireclay pipe is usually one-tenth of its

internal diameter, while that of a stone-ware pipe is one-twelfth. Stone-ware pipes, 4, 5 and 6 in. in diameter, are made 2 ft. 6 in. long, larger sizes, 3 ft. long. All fireclay pipes are made in 3 ft. lengths.

Stone-ware pipes are more brittle and more difficult to cut than fireclay. In large pipes, when the flow is strong and continuous, cases have been found where the internal coat of glaze on fireclay pipes has been worn through, but this would seldom happen in house or stable drains.

Traps and other drain fittings are made of the same materials as those used for pipes.

Cast-Iron Pipes.—In connection with the drainage of buildings three classes of cast-iron pipes are commonly used. *Rain water pipes* are intended only for conducting the discharge from roof

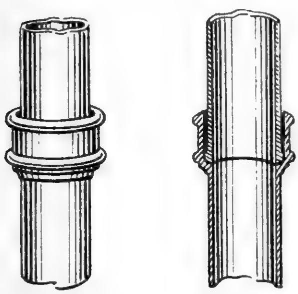


Fig. 10.—Soil and Waste Pipe. Staved Joint.

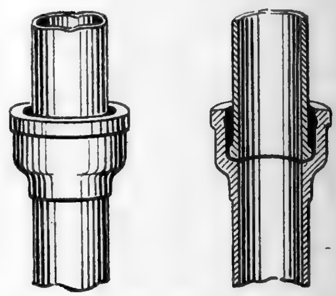


Fig. 11.—Heavy Drain Pipe. Staved Joint.

gutters to the ground level. They are of very light metal, and the faucets are not suitable for lead caulking. These pipes should never be used for soil or waste pipes. *Waste* and *soil pipes* of $^3/_{16}$ inch and $\frac{1}{4}$ inch respectively are cast with care to ensure a smooth internal surface. The sockets are of sufficient width and strength to permit the joint being properly caulked. The pipes are made in 6 feet overall lengths.

Cast-Iron Drain Pipes are made of specially heavy design with extra strong sockets. The joint is made of rope yarn and molten lead properly caulked into the annular staving space. This joint is the most air-tight, and there is little possibility of the leakage of sewer gas. The smooth internal surface which is necessary in a drain pipe is obtained by a special treatment of the core. All bends, junctions, &c., are made with very easy curves to facilitate the flow.

The strength of cast-iron drain pipes, combined with the elasticity of caulked lead joints, enables the pipes and joints to sustain without damage subsidence of ground and other accidents which

would inevitably prove the ruin of fireclay or stone-ware pipes. Drain pipes are made in 6 feet effective lengths (*i.e.*, exclusive of the depth of socket), and also in 9 feet lengths.

Cast-iron waste, soil and drain pipes after being cleaned from all sand and rust are usually coated inside and out with Dr. Angus Smith's solution, a well-known preventive against corrosion. The pipes are dipped vertically into a mixture of coal tar, pitch and oil, heated to a temperature of 400° F. After remaining long enough to acquire the necessary temperature and to ensure the thorough penetration of the solution into the pores of the metal, they are withdrawn and allowed to cool gradually. Soil pipes are sometimes galvanised, and both soil and drain pipes are often glass-enamelled, a process which imparts a perfectly smooth glazed surface to the interior of the pipe.

Pipe Connections.—As the object of a good drainage system is

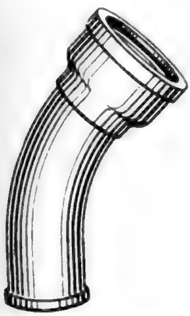


FIG. 12.—A Bend.

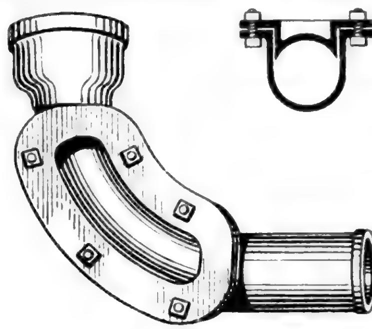


FIG. 13.—An Inspection Bend with bolted cover.

to convey sewage to the sewer or cesspool as expeditiously as possible and with the minimum of checks on the way, lengths of piping must be laid in as straight a line as possible. Bends in the course naturally check to a certain extent the even flow of liquids, but they are often necessary and unavoidable. Special curved pipes called *Bends* are used when abrupt deviations from the straight are necessary, and by the use of these specially constructed pipes the flow is checked as little as possible. Sharp curves must not be made by joining up small lengths of straight pipes as not only is the flow seriously checked, with consequent sedimentation, but joints so made are of necessity imperfect. As it is at curves that chokage is liable to occur through the holding up of rubbish which should not have entered the drain, curved pipes are provided with removable hand hole lids and inspection shafts fitted with a manhole cover to give access from the ground level.

Junctions.—Where one pipe joins another the junction must be effected so that the inflow of sewage runs smoothly into the main

pipe in the direction of the main flow. Junctions at right angles are therefore to be avoided as a body of sewage so entering strikes the opposite side of the main pipe, its own flow is checked and also

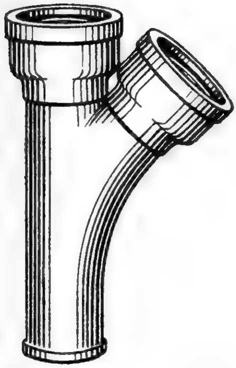


FIG. 14.—A Junction.

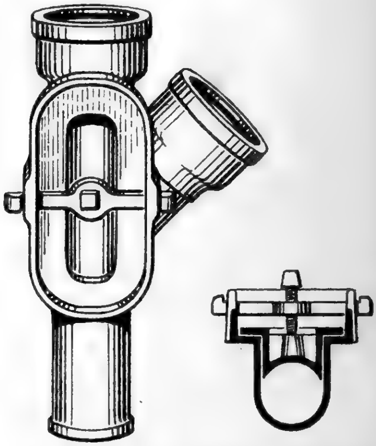


FIG. 15.—An Inspection Junction with bridled cover.

that of the main current, part of the inflow is turned aside up the main pipe and the general stoppage of flow leads to sedimentation through the swirling action with resultant blockage.

Where there are several subsidiary pipes in a system it is advisable that these be laid to converge at a common point so that there may be convenient access to a number of junctions at one inspection chamber. With modern cast-iron fittings special inspection

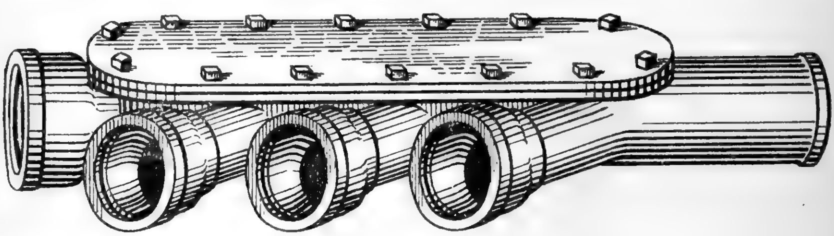


FIG. 16.—Inspection Chamber with bolted cover.

chambers are made with a variety of junction pipes. The smooth inflow of sewage is ensured. Access is easily accomplished by removing the lid which is securely bolted down with gunmetal bolts or by means of a bridle. A layer of prepared felt interposes between the cover and the rim of the chamber so that the latter is rendered both gas and water proof. If necessary, at the point of convergence of tributary pipes these can be disconnected from the distal drain or sewer by joining the chamber to a disconnecting syphon trap, and for convenience in clearing away any obstruction

this may be provided with a raking arm as shown in the figure. Access covers for fireclay fittings are luted down with a mixture of lime and cement.

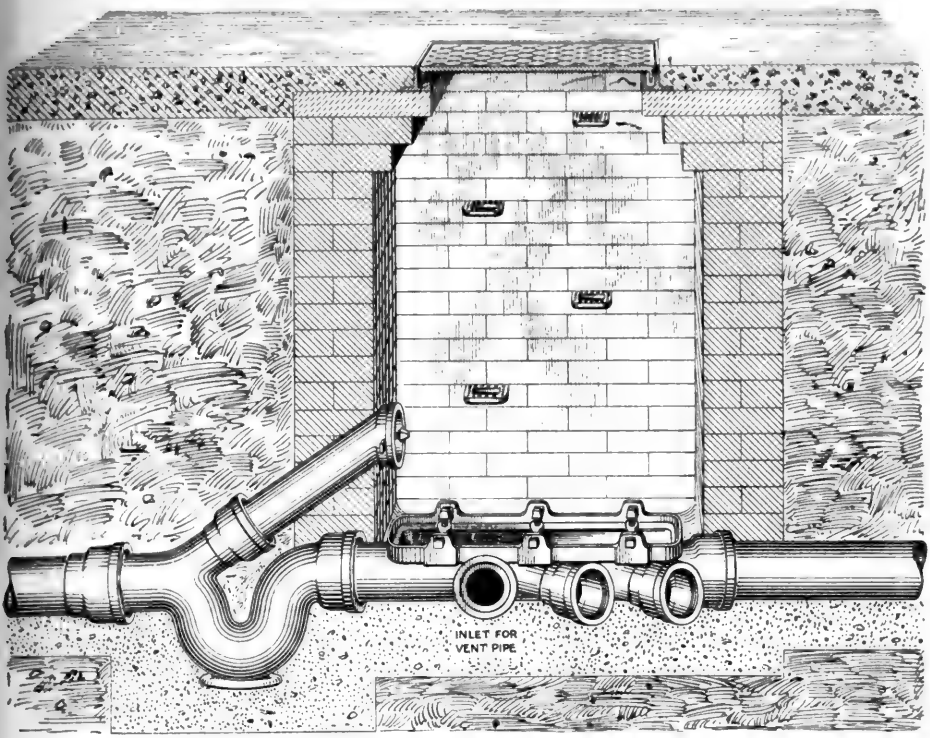


FIG. 17.—Section of Manhole showing combination of inspection chamber, disconnecting trap with clearing arm, iron steps and manhole cover.

The Size of Pipes.—If a certain volume of water flows at a certain speed through a pipe having a diameter of, say, 4 inches, the same volume of water will flow at a reduced speed through a pipe set at the same gradient but having a greater diameter. The volume of water will be spread over a wider area and the amount of friction would therefore be increased with consequent retardation of the flow. Not only is the flow reduced in speed, but the volume is reduced in depth and the slower the speed and the shallower the sewage the greater opportunity is there for solids to be left behind in the pipes as the liquid passes on. If actual blockage does not occur silting to a certain extent is certain to take place, with the consequence that the stranded filth decomposes in the drain and fills it with noxious sewer gases. Such filth is only removed when an unusual flush takes place. The size of drain pipes should therefore be as small as possible, allowance being made for the estimated amount of "drainage" to be carried and for possible flooding

during heavy rain storms. It is very seldom that drain pipes run full bore—probably only in some street drains, and then only in exceptional circumstances. The more nearly full drain pipes are kept running with water or sewage the cleaner they will be, and the less chance there will be of silting and its resultant evil consequences. For the average stable or cow byre it will be found that a 4 or 5-inch pipe will be big enough.

The Gradient of Drain Pipes.—The condition of the interior of drain pipes depends very largely upon the rate at which the sewage passes through them. The velocity of the flow depends primarily upon the gradient at which the pipes are laid. Other influencing factors are:—the size of the pipes as has been mentioned; the course taken by them, that is, if it is a straight or a curved one; the number and character of bends and traps; the character of the internal facing of the pipes, as a rough surface naturally causes more friction than a smooth one; the workmanship displayed in laying the pipes and fittings and the character of the sewage.

A satisfactory gradient is one which will ensure a steady and even passage of both fluid and solid portions of the sewage, or in other words a self-cleansing velocity. The liquids should not run so slow that the solids have an opportunity to settle out, neither should the flow be too rapid, as in this event the water entering a trap at too great a speed is inclined to empty it by syphonic action or at any rate to leave too small a volume behind to form an effective seal, the nature of which is described below.

For ordinary house or stable drains a speed of three and a half to four feet per second is satisfactory and this is attained in a 4-inch pipe if there is a gradient of one in forty, and in a 6-inch pipe with a gradient of one in sixty if the pipes are running at about one quarter full.

Traps.—A trap is a contrivance for preventing sewer gas escaping into the house drainage system, or for preventing any gases generated in the portions of the house drainage system which convey soil water passing into those portions which convey cleaner water, or into the building itself. Every form of trap is a nuisance, but a nuisance which is very necessary. A trap may be so badly constructed as to be a greater danger in itself than if none were present. On the other hand, a well-designed trap properly laid serves its intended purpose with the minimum of objectionable features.

Since the earliest days of traps the same fundamental principle for holding back gases has been in use, that of the interpolation of a body of water in the drain between the sewer and the house

or other building. While the principle has remained, and is likely to remain the same, the details of the construction of traps have undergone great modification and improvement and in place of the very insanitary and dangerous fittings of former days, which were nothing less than hidden cesspools of the worst type, there are in use to-day traps of simple design which effectually do their work with the minimum of defects.

If a length of pipe be bent as in figure 18 and placed horizontally or on a slight gradient it will be obvious that if water flows through it on account of the gradient given to the line of piping and the trap, a body of water will remain in the bent portion after the influx has ceased, provided, of course, that the gradient be not too steep. As the upper part of the pipe has been bent correspondingly with the lower, or invert, it will be plain that the bent-in portion will project below the level of the outlet and consequently will dip into the body of water which is retained. So long as there is water standing well above the lowest point of the bent-in portion of the pipe, no gases can find their way up the drain without passing through the retained water which they do not do unless they accumulate under great pressure and force their way through. If the pipe or trap is not frequently flushed the stagnant water may, of course, absorb the gases from the sewer side and pass them through. Under ordinary conditions, however, this body of water forms a " seal " which shuts off the drain on its distal or sewer side from the proximal or house side.

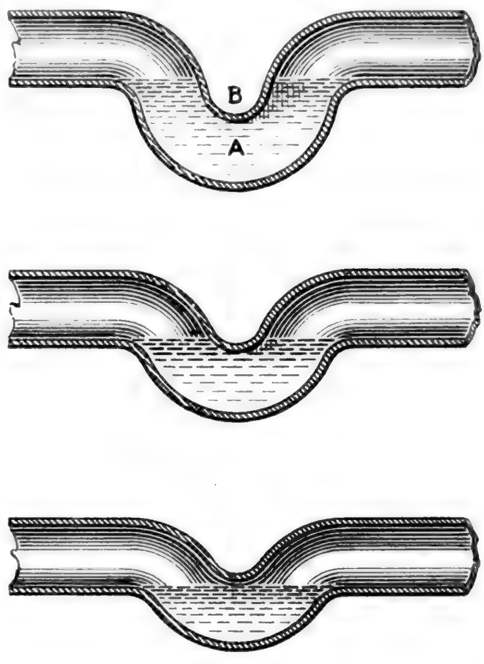


Fig. 18.—Three sections of Simple Syphon Traps. The top figure shows a satisfactory seal A-B, the next figure shows a seal that is too shallow, and the bottom section a pipe that is not sufficiently bent to form a seal.

The reliability of a trap depends in the first place upon the depth to which the in-bent portion or lip dips into the water. This dip-

ping in of the lip constitutes the *seal,* and the depth of the seal is measured by the distance to which the lip dips into the water. If the pipe is not sufficiently bent, or in other words if the lip does not dip sufficiently into the water, a seal too shallow for safety is formed as it may be broken with very little reduction in the volume of water as is indicated in the figure.

Definition of a Good Trap.—A satisfactory trap must effectually prevent sewer gases under ordinary circumstances from passing up the inlet pipes. It must be self-cleansing, so that a moderate influx of water should carry all the trap water before it and leave no sediment behind. It must be of simple structure, have no movable parts and no sharp angles or corners. The internal diameter of

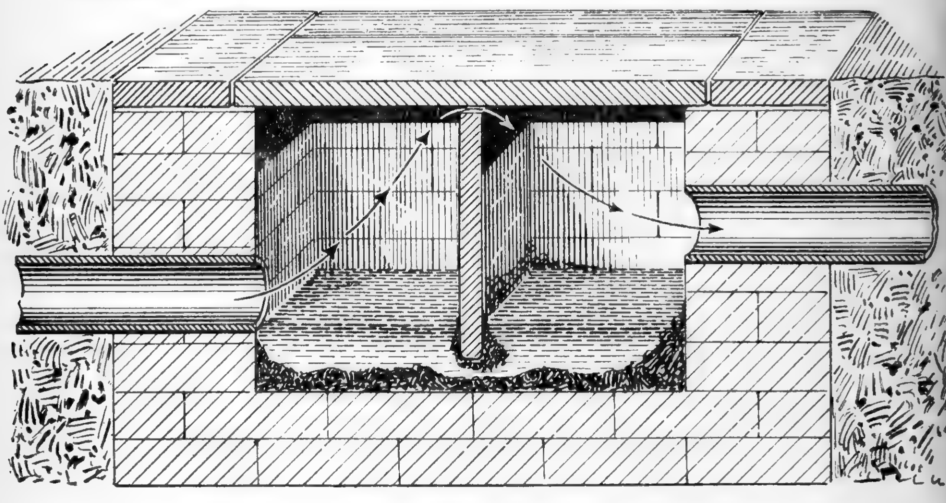


FIG. 19.—A Dip-Stone or Mason's Trap showing the accumulation of sediment. The back passage of sewer gas over the top of the dip-stone is indicated by the arrows.

a trap should be the same throughout, except in the case of some special forms. It must have a square base so that it can be set firm in the ground without there being any risk of tilting, with consequent reduction in the depth of water in the seal. The inlets and outlets must be capable of forming perfect joints. An air inlet hole for ventilation must be provided on the proximal or house side, and a hand hole on the distal side for the purpose of removing any possible chokage.

Traps should be so laid as to be readily accessible. The depth of seal should be such as to obviate any ordinary risk of reduction to danger point by evaporation or waving; a suitable depth is from 2 to 3 inches. The trap should contain just sufficient water, and no more, to guarantee a safe seal. If the depth of seal is too great, or too much water is retained in the body of the trap, there is a

probability that it will not be completely removed with a moderate flushing. It is advisable for the inlet to provide a sudden fall so as to give some impetus to the outgo of sewage, but the outlet should be more gradual so as to render easy the discharge of solids.

One of the earliest forms of traps is the *dip-stone, masons* or *built* trap. This, as the figure shows, is a receptacle built of brick or other mason's material for containing a body of drainage into which dips a flagstone which is supported by being built into two sides of the structure. The dip-stone is supposed to prevent the backward passage of gases into the inlet pipe. It is one of the worst forms of traps and is figured for the purpose of showing its bad points. Owing to the nature of its formation there is liable to be a settlement of part of the structure with resultant leakage at the top of the dip-stone, and the whole fabric may allow sewage to escape into the surrounding ground. The trap is not self-cleansing, and indeed it is impossible to clean it out thoroughly by any method. The dip-stone becomes coated with organic scum, which remains to decompose and give off noxious gases which pass up the inlet pipe. Solids settle to the bottom of the chamber, accumulate, and gradually putrefy on both sides of the seal. It is indeed a "trap," but not in the sense that is intended to be implied.

Figure 20 illustrates the trap in use to-day. It was designed by Buchan and is called *Buchan's Disconnecting Syphon Trap.* The illustration shows that it is provided with an abrupt inlet and a gradual outlet. It might be thought that the water on entering this trap would strike the perpendicular wall facing the inlet and thus check the flow; this, however, is not so because, should the water enter with sufficient force to carry to the opposite side of the inlet, then the pipe would be running full bore and there would be no question of the trap not being completely flushed. Should the pipe be running less than at its full capacity, the sewage would fall over into the centre of the trap, thus forming *Buchan's Cascade,* the object of which is to break up any scum that may have formed on the surface of the water seal. The seal in this trap is very effectual, and the body of water retained is just sufficient and no more to fulfil its intended

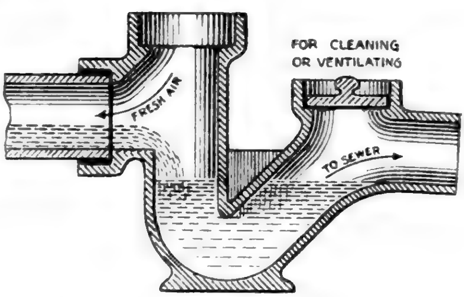


FIG. 20.—Buchan's Disconnecting Syphon Trap. Note the abrupt inlet giving a cascade action to the inflowing fluid.

purpose and is, therefore, completely changed with a moderate flushing. Buchan's *disconnecting* or *intercepting* trap, or some modification of it, is in general use to-day for the purpose of completely cutting off the sewer from the house drain. The inlet side of a disconnecting syphon trap is provided with an opening to allow of the free passage of air into both trap and piping. This keeps the air in the pipe fresh and at atmospheric pressure, and at once disconnects the house pipes from the sewer pipes. This air inlet communicates with the air at or about ground level by means of a length of suitable pipe. At the outlet end of the trap there should be a hand-hole fitted with a lid well luted down with clay or cement in the case of fireclay fittings, or luted with prepared felt and bolted down in iron fittings. This hole provides access in case of chokage, and through it clearing rods can be passed to move on the obstruction.

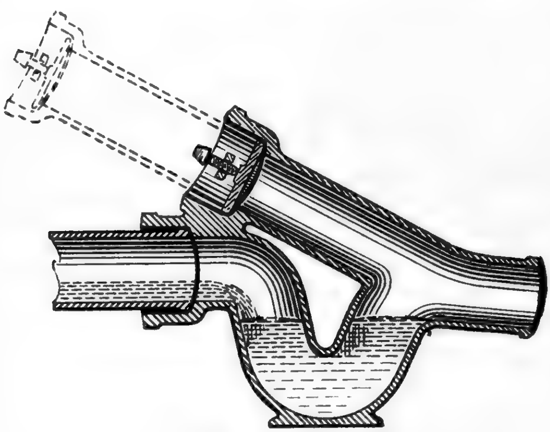


FIG. 21.—Disconnecting Trap with clearing arm extension.

With some traps the hand-hole is extended to form a *raking-arm* which makes it more accessible; this is shown in figure 21. The hand-hole may also, if required, be used as an outlet for sewer gas, in which case the pipe connected with it is carried above the level of the eaves and well clear of windows.

When a disconnecting trap of Buchan's or similar design is made in one piece there is often difficulty in making a good connection with the pipes at either end, owing to the angle at which they have to meet the trap. To overcome this the trap is conveniently made in two sections, a head-piece fitted with the inlet and ventilation hole and the syphon trap itself. Thus trap and head-piece may be pivoted in any direction required, and perfect jointing can then be ensured.

With a house drainage system all the excreta, both soil and waste water, is conveyed away as useless and dangerous material to be got rid of as expeditiously and as economically as possible, the chief object in view being to safeguard the health of the populace. With animals, on the other hand, both liquid and solid excreta

are valuable assets, at any rate to the farmer, and according to the use made of excremental products the success of farming to a large extent depends. In towns the cost of transport is often greater than the value of the manure, unless the supply is both large and constant. Not only is the monetary value of the manure less but its danger from a hygienic point of view is far greater, and it must be remembered that stored horse manure is a favourite breeding ground for flies. Consequently all animal excreta in populous places must be considered merely as waste products much in the same light as human excreta.

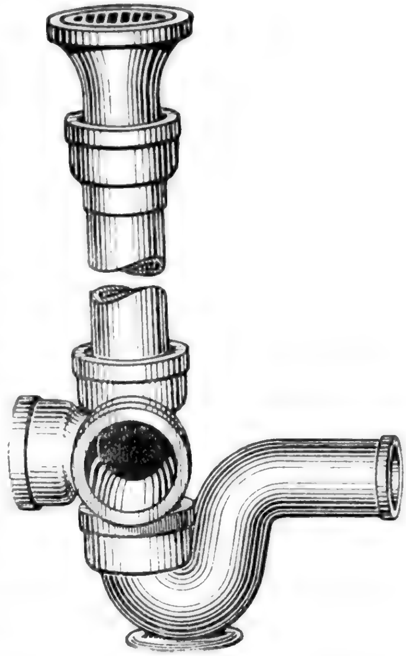


FIG. 22.—Combination of Syphon Trap, adaptable inlet piece, and ventilating shaft.

While the urine of animals can pass down the drains into the common sewer when the animals are stabled in a town, the nature and bulk of the so-called solid portion is such that any attempt to remove it by the common channel would speedily end in disaster. It is therefore obvious that special traps must be used in connection with animal habitations which will let the fluid pass into the drain and at the same time hold back the more solid portion. For this purpose *Gully Traps* are placed at the inlet of the drains; they are specially designed to catch and retain any solid matter that may be washed into them and which, but for their presence, would be carried into the drain. Their usual form is that of a somewhat deep rectangular box with an inlet at the top provided with a grating which is placed at the surface level. The invert of the outlet is usually about two-thirds the distance from the bottom of the trap, and the seal

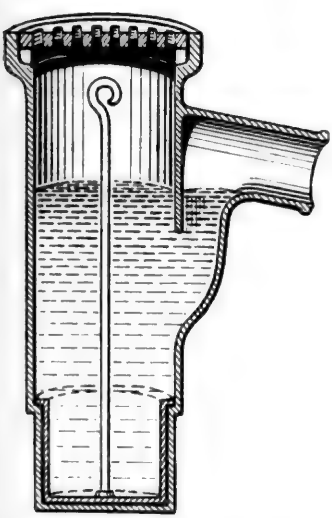


FIG. 23.—Dean's Gully Trap with a flat bottom and sediment pan.

is formed by a lip which dips down two inches or so into the water below the outlet level. The lip should be so placed as to offer no obstruction to the removal of sediment. Many gullies are provided with a bucket to facilitate the removal of the solids. These traps are placed wherever a stable drain enters a common drain and in other places where there is likelihood of much sediment being carried by surface water, such as in the surface channels at road sides.

Since the professed object of any system of drainage is to remove as speedily and as safely as possible all decaying organic

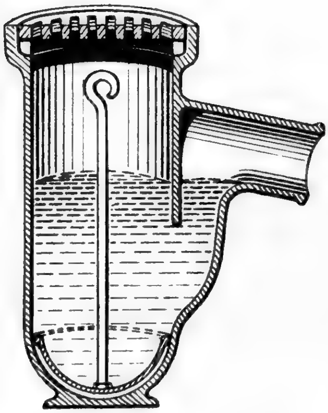


FIG. 24.—Dean's Gully Trap with a round bottom and sediment pan.

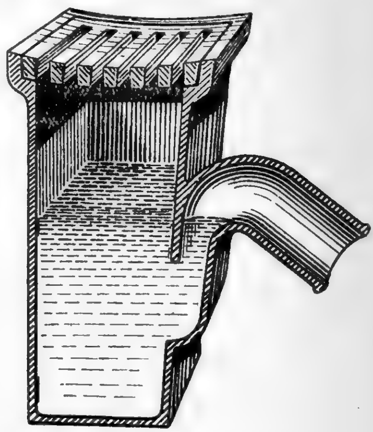


FIG. 25.—Road Gully Trap.

matter, it will be obvious that any gully trap that is not self-cleansing, and this none of them can be, can hardly be regarded as a "sanitary" fitting. The filth that collects in them usually gets leave to stay there until the trap gets choked and attention is drawn to the fact by the overflow of foul-smelling fluid, at least that is the case with most stable traps though street gullies receive more attention. The collection of decaying organic matter gradually decomposes, giving off in the process gases which pass freely into the air, not uncommonly immediately outside a stable door or directly under a stable air inlet.

Figure 26 shows a type of gully now in common use. It is fitted with a deep bucket, which is perforated at the top for an overflow into the trap proper and which has an inlet fitted with a deep lip so constructed as to guide solids into the bucket and which, at the same time, acts as a seal of a sort by dipping into the liquid in the bucket. This particular type of gully possesses no real advantage over the more simple, and it is certainly more difficult to clean.

The evils of the street gully have been pointed out by Dr. J. T.

Neech* who rightly condemns the practice of emptying the filth on to the streets where it is only partially cleaned up and where the remainder on drying is blown into the air and into the windows of houses; it does not appear at present, however, that anything can take its place owing to the amount of sand and similar debris that gets washed into it.

As the object of a gully trap is merely to prevent much solid

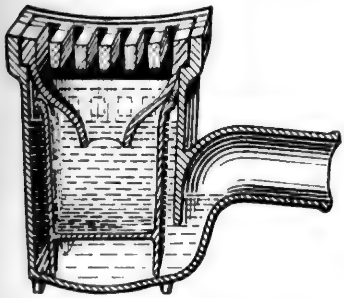


Fig. 26.—A Double-Seal Gully with sediment pan.

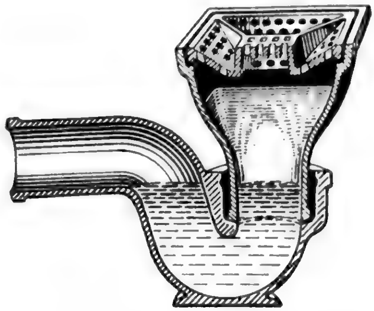


Fig. 27.—Linton's Gully Top with low back syphon trap.

matter from entering the drain, all that is required for this purpose is a suitable grating to an ordinary self-cleansing syphon trap for use in stable yards and similar places. The author, in co-operation with Mr. Dorsie, with this idea in view designed the trap here figured which has been manufactured by Messrs. Cameron and Roberton of Kirkintilloch.

A form of trap at one time in much favour for use in sinks, court-yards and other places to trap surface water or slop waste is shown in figure 28. This is the *Bell* trap. It is made in two pieces, a lower part which is the water container, and an upper part which is the inlet grating to which is attached a lip in the form of a bell or inverted cup which dips into the water contained in the lower part and so forms a seal. It is a very dangerous form of trap and should never be used. Its most obvious disadvantages are:—the seal is too shallow; the lip being attached to the grating, the seal is broken each time the grating is removed for the purpose of cleaning the trap and sewer gas can then pass freely into the air; it becomes very easily choked; owing to the shallowness

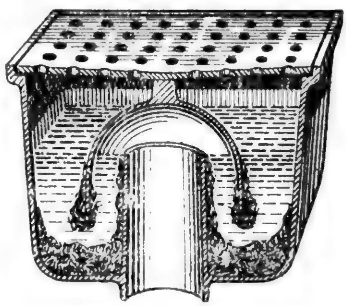


Fig. 28.—Bell Trap showing the deposit of organic matter.

* The Insanitary Gully, *Journ. Roy. San. Inst.*, Vol. XXXVII., No. 3, Sept., 1916, p. 141.

of the water-container the water is soon evaporated when in exposed places; the bell is easily broken. This trap may be found in old buildings.

Grease Traps.—Grease traps are used for the purpose of con-

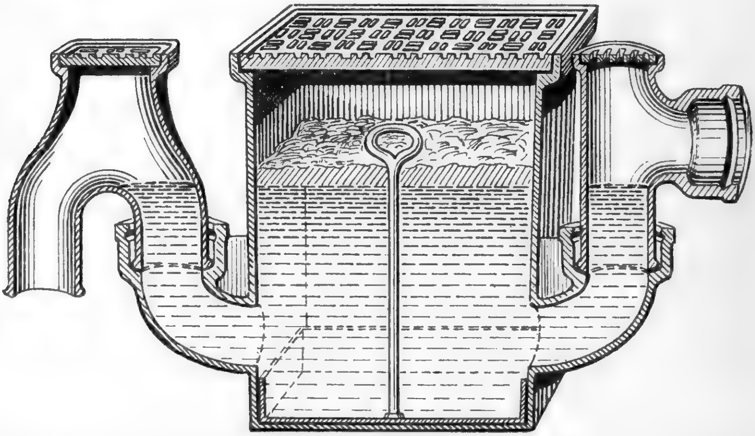


FIG. 29.—A Grease Box with a sediment pan, a ventilated inlet and a sealed outlet.

trolling the passage of grease from the house sink into the drain. Hot grease on entering the cold water in a pipe or trap solidifies and is apt to cause a blockage. There are two methods of treating this nuisance. The grease may be retained in a trap and be periodically removed or it may be passed into a trap so designed that the incoming water breaks up the film of solid grease that forms on the top of the water so that it is carried away in small lumps to the outfall. Figure 29 illustrates a cast-iron grease trap fitted with a container bucket for the removal of the solidified grease. Such a trap should be cleaned out at least once a month. Figure 30 shows a more satisfactory form of grease trap, it is self-cleansing and requires no attention. Grease traps are not necessary for private houses and are not used to such an extent as formerly.

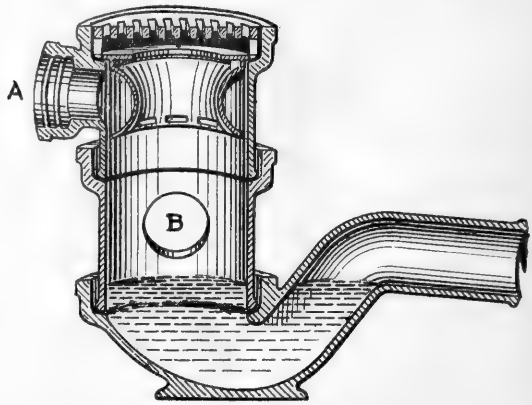


FIG. 30.—A Self-Cleansing Grease Trap with a flushing rim. A. Inlet for Flush. B. Inlet for Waste.

JOINING PIPES AND FITTINGS.—All joints must be made perfectly gas and water proof, and the material used for sealing the join

must be able to resist the action of fluids from without and of fluids and gases from within. To make a perfect joint, contiguous pipes must be in true alignment and remain so when the jointing material has set. The joint must be well filled and none of the filling must be allowed to project into the lumen of the pipe; any such is removed before the next pipe is laid with a special form of brush or scraper called a badger. It is essential that the joint be durable and able to withstand any gas or water pressure that might, under exceptional circumstances, be put upon it.

Clay, at one time used for making joints, is very unsuitable; not only has it a short life, but the weight of the pipe and superimposed earth soon forces it out of position, and the joint then becomes faulty. One part of Portland cement and one part of sand makes the best jointing material for stone-ware or fireclay pipes. The insertion of a rope gaskin prior to filling with cement is sometimes advocated; sanitary engineers of experience, however, do not recommend its use as it is apt to protrude into the lumen of the pipe and cannot be removed by the badger. If the gaskin be of tarred rope it forms a permanent obstruction offering every inducement for the lodgment of solids; if of untarred rope it soon decays and the joint becomes faulty, sewage collects in the space left by the decayed filling and there undergoes decomposition with liberation of foul gases. For iron pipes and fittings lead is used as a filling, the spigot of the pipe has cast on to it a slight ridge which prevents the gaskin from entering the pipe; when the gaskin is well rammed into place molten lead is run in and when cold well caulked.

There are many patent joints on the market, the principle of nearly all of them being to cast on the spigot and in the faucet a thin ring of bituminous material in accurate moulds, so that when the spigot is inserted in the faucet the pipes are bound to be in true alignment and practically water tight. This does away with the use of gaskin and ensures that none of the filling protrudes inside the pipe. Where pipes have to be cut such patent joints are obviously a disadvantage. They are very useful in laying long stretches of pipes in wet situations, but are much more expensive than ordinary pipes.

There is a new and excellent type of faucet for fireclay drains made by Messrs. J. & R. Howie, Kilmarnock, and known as the Hutchison faucet. It consists of an additional check or rebate at the foot of the faucet into which the plain spigot enters. This disposes of the use of gaskin in making the joint, and ensures the true alignment of the bore of the pipe.

Comparison between Fireclay and Iron Pipes and Fittings.—The use of cast-iron for drain pipes and fittings certainly possesses some advantages over fireclay. Many of the faults, however, found with fireclay are not inherent defects but due rather to bad material, bad workmanship and bad supervision. The laying of fireclay pipes undoubtedly calls for more supervision than for iron pipes.

If the pipes are good, free from cracks and faults, the joints properly filled, and the pipes laid in cement concrete where the ground is soft, the result will be satisfactory. Fireclay pipes when well laid are always cleaner than iron drains and will in ordinary circumstances remain *practically* tight for long periods; on the other hand iron pipes will remain *perfectly* tight for long periods but do not remain for any length of time perfectly clean. For drains under or in close proximity to habitations iron fittings possess many advantages, especially tightness, and the fact that much better fittings in the way of branches, accesses, bends, traps, &c., can be obtained in iron than in fireclay. For long lines removed from habitations fireclay is quite good. It has, however, always to be borne in mind that, owing to the greater length of iron pipes, fewer joints are required than with fireclay pipes.

The Laying of Drains.—In laying drain pipes and fittings in a trench great care must be taken to see that the trench has a good firm bottom, and that it is not made up with loose earth. If the soil immediately underneath the piping is of a loose nature, subsidence is bound to occur and considerable strain thrown upon sections of the pipes, so that either the joints become loosened and imperfect or the pipes may actually fracture. The obvious result of such a settlement is that the soil becomes saturated with sewage matter, or sewer gases escape into the soil with probably dangerous consequences. Such defects are, of course, not discovered until harm has been done, which draws attention to the probable leakage. In order that the body of the pipe can lie flat on the bottom of the trench, a slight excavation is necessary to receive the faucet. In filling the trench great care must be taken to see that the pipes do not get displaced. The finest of the earth must be used for the first filling and be carefully rammed in to prevent rolling of the pipes. The rougher material containing stones should be put in later as there is then less chance of stones fracturing the fireclay when they are rammed down. If the soil is of a loose character it is well to make a good solid bed of concrete for the pipes to lie on, and with fireclay pipes, especially if running under buildings, the whole pipes may be surrounded with cement concrete. This is, however, an expensive business, and entails much labour and difficulty in getting

at the pipes on subsequent occasion should this be necessary for effecting repairs or for making new connections.

It is important that all traps be set in a firm bed of cement concrete so that the water seal may remain at the proper level.

Defects.—From the foregoing it will be seen that defects in drains may be due to several causes, and these may be summarised as follows:—(*a*) blockage of the pipes or fittings through the entrance of large objects; (*b*) insufficient gradient, or, conversely, too steep a gradient; (*c*) want of ventilation resulting in the syphonage of traps when a w.c. or sink containing a large quantity of water is let into the drain; (*d*) "waving" of the water in a trap due to alteration in the air pressure of adjacent pipes, usually set up by wind, and resulting in the reduction of the seal; (*e*) insufficient flushing of the drains resulting in reduction of the seal in traps by evaporation; (*f*) imperfect laying of traps so that these become tilted out of line, so reducing the depth of the seal; (*g*) bad workmanship in laying drains, such as imperfect alignment and the access of cement into the pipes at the faucet during the joint making; (*h*) imperfect luting of inspection covers; (*i*) using pipes too large, or, conversely, too small; (*j*) imperfect ventilation of lengths of piping, so that sewer gas accumulates under pressure and forces the water seal of a trap; (*k*) imperfect flushing of the system with the result that solids accumulate and gases generate; (*l*) subsidence of the soil with consequent sagging and rupture of pipes of their joints; (*m*) use of unsuitable substances, such as clay, for jointing material; (*n*) too many bends in a system, or these improperly made; (*o*) junctions not effected at a suitable angle.

TESTING DRAINS.—Drains must be tested to ensure that they are gas and water tight, and that the water seals of the traps are satisfactory. Tests are carried out on the various sections of a drainage system during its construction, and a final test on the whole system when completed. Thereafter periodical tests should be made from time to time to ascertain that the system remains satisfactory, as defects may develop from various causes which, if not rectified, may cause serious danger to health.

There are various methods of testing drains but those generally in use are:—

(1) The Air or Pneumatic Test.
(2) The Smoke Test.
(3) The Water or Hydraulic Test.
(4) The Scent or Smell Test.

The Air and Smoke Tests.—The air test consists in plugging

up the open ends of the drains and ventilating pipes and pumping in air under pressure sufficient to indicate on the gauge used. If the gauge does not show that this pressure is being maintained, it indicates a leak or leakages. These can generally be located by filling the pipes with dense white smoke, afterwards plugging the pipes and applying the same pressure as before. This will force the smoke out at the defective parts and enable them to be located and made good. This test should be continued until the gauge remains steady and proves that the drains are sound and can be passed as satisfactory. Any desired pressure can be applied and the air or pneumatic test can be made very severe, in fact a greater pressure can be exerted inside the pipes than could ever occur under ordinary circumstances. Under normal conditions, however, there is little or no pressure inside the drain pipes, so that an apparatus that will give about $\frac{1}{2}$ oz. pressure per square inch will apply a sufficient test both to the drains and to the trap seals. One inch head of water represents $0 \cdot 577$ oz. per square inch, and as the seal for small traps is usually $1\frac{1}{2}$ to $1\frac{3}{4}$ inches they should be able to stand a test of $\frac{1}{2}$ oz. pressure.

The best apparatus for applying the air and smoke tests (either for high or low pressure) is the Burn and Baillie Patent Drain Testing Machine, which is a combined air and smoke testing apparatus and can be used for either or both tests as above described. It consists of a copper cylinder in which is burned specially prepared smoke paper, or cotton waste soaked in whale oil (paraffin should not be used as it is liable to flare in the box). The cylinder is surrounded by a copper tank which is filled with water to keep the fire box as cool as possible. A copper cover or float is placed over the cylinder which, dipping into the water in the tank, forms an air-tight joint. A strong double action bellows is connected with the fire box. When using the apparatus for the air test the tank is filled with water and the float put in position. Rubber or flexible metallic tubing connects the outlet of the machine and the drain to be tested. Fresh air inlets and all air outlets are closed with rubber stoppers and air is then forced into the drain with the bellows, a few strokes of which causes the float to rise. If the float remains stationary, after the stop-cock on the apparatus is closed, the drain is tight, but if it falls a leak is indicated. In order to detect the position of the leak or leaks the smoke test may then be applied. The smoke paper or cotton waste is placed in the cylinder and lit, the bellows are worked, and when dense smoke is formed the cover is put on and the smoke blown into the drain. The plugs at the air inlets and outlets are removed until smoke issues

freely, when they are replaced. The weight of the float is so adjusted by the makers that no greater pressure can be applied without forcing the smoke out at the cover than can be resisted by the water trap of ordinary depth.

The Hydraulic Test.—With the hydraulic test the outlet of a drain, or a section of it, is plugged with an expanding rubber bag or other patent stopper and the section to be tested then filled with water to a pressure of a head of from 6 to 10 feet. The water is left in for two or three hours and if a leak exists its presence is indicated by a fall in the head of water at the point of observation. A dry day should be chosen on which to make the test. It will be obvious that the pressure at the outlet end of a big system will be much greater than at the higher level. For this reason some objection is taken to the hydraulic test, it being alleged that the test should be most severe at the house or stable connections. This, however, is no conclusive argument, as the greatest strain on a drainage system is at the distal end where a choke is most likely to occur.

The Smell Test.—An old method was to pour oil of peppermint down the drain followed by hot water. If there is a leak in the system the smell of the peppermint would be detected. An improved method of applying this test is by a special apparatus introduced through the seal of a trap, which liberates after it has passed the seal a mixture of calcium carbide and asafœtida. Should there be a leak a most pungent and penetrating odour is soon detected. While the smell test for routine practice is not now generally used it has its special advantages for certain situations, as, for instance, at the top of a tenement building far removed from actual drains where it is desired to try the joints and fittings of that particular house. Kinzett's Patent Drain Tester is the most useful for this purpose.

Drainage Systems for Animal Habitations.—There are two systems of drainage :—(1) *Surface Drains* and (2) *Underground Drains.* A surface drainage system is one where the matter to be conveyed away is carried in open channels on the surface of the ground. Underground drains carry the effluent in pipes out of sight under the soil.

Until comparatively recent times it was the custom to use underground drains for the interior of all animal houses, and especially in stables. This system has been superseded by the surface method. With the old system it was the custom in the case of a stable to have a pipe running the length of the building behind the stalls and for the urine of each stall to trickle through a trap into the pipe. In

the loose-box a gully trap was placed in the centre of the floor, which was graded from all the sides of the box to the gully. The main stable drain was trapped outside the stable before joining up with the sewer pipe, or passing to the manure pit or liquid manure tank, as the case might be. There are two chief objections to underground drains for animal buildings. With whatever kind of trap is used in the stable a certain amount of solid always finds its way into the drain. The amount of fluid that enters the traps and pipes is very small and consists almost exclusively of urine. It is not difficult to understand that both traps and pipes become receptacles rather than carriers of urine and manure which decompose with the liberation into the stable of objectionable gases. The smell that arises from these traps when they are cleaned out, which, as a rule, is only done when they become blocked, is nauseating. Stables are not, as a rule, frequently washed out but when they are underground drains get choked. When peat moss is used for bedding it is necessary to close up all such drains and traps to prevent the urine-sodden moss from getting into the pipes. Wherever underground drains are installed, and they are to be found in many old stables to-day, foul smells and a great deal of trouble invariably follow.

With surface drainage there is nothing but a shallow open channel running down the length of the stable, to pass, still as an open channel, through the wall to empty into a trap out in the open air. The advantages of this system over the old one are at once apparent. There are no traps to get blocked, there is no formation of sewer gas to poison the air, and there is a great economy in construction. In order to keep the floor of a stable clean, all that is required after the animals have gone out in the morning is to make up the beds and flush the stall centres and urine channel with a few buckets of water and brush down. It is sometimes suggested that the channel after it has passed through the wall should continue as an open channel for a dozen feet or so before discharging into the trapped drain. This is quite unnecessary, because if the drain is properly constructed and the trap kept flushed with water there can be no objection to having it immediately outside the building. Where there are several loose-boxes in a row, that is "outside" boxes, it is a mistake to provide each with its own trap and junction pipe; a dozen boxes and a dozen traps means that not one of the dozen will be kept flushed and clean, but with one trap at the centre of the row and a surface channel connecting the other boxes to it there will be more likelihood of it being properly attended to. The form of trap advocated for this purpose is shown in figure 27. This is a self-cleansing trap and only requires flushing with water.

The drainage of a cow byre is not so simple as that of a stable. This is due to the difference in the character of the fæces, the large quantity of both the semi-solid and liquid excreta, and to the fact that during the winter the animals are commonly kept in the house day and night. The dimensions and configuration of the surface channel will be described later. As the semi-solid dung and dirty straw collect in the channel it is removed from time to time and conveyed to the manure pit in barrows or manure-carriers. The quantity of fluid and semi-solid that passes on to the channel-exit is considerable, and in addition a large quantity of water is, or should be, used to flush down the byre to keep it clean and free from dust. The nature and quantity of the material that passes down the channel and is not removed by hand is such that an ordinary retaining or gully trap is quite inadequate to deal with it. On the majority of dairy farms this difficulty is got over by placing a sump or catch-pit just outside the byre in the place of the gully trap used for stables. This catch-pit, or enlarged gully trap, holds back the solids and lets the liquids pass on through a pipe to the liquid manure tank. Owing to the large volume of water that is used to wash down a byre, a good plan that is sometimes adopted is to have two outlets at the end of the channel controlled by valves. One outlet allows the urine and first wash-water to pass to the manure tank, and the second, which when opened automatically closes the other, lets the wash-water, which has practically no manurial value, pass to the waste drain.

The drainage of piggeries and all other animal houses should be as simple as possible. Only shallow surface drains should be used and no traps of any kind allowed inside the buildings.

Disposal of Manure.—On farms every effort should be made to conserve as much as possible of the liquid and solid manure, as both have a considerable financial value, and it is possible to do this without creating a nuisance. A system of collection and storage naturally falls under three heads. The initial collection of the more solid manure and its removal from the stable, byre, &c. The conveyance from the building of the liquid manure and such semi-solids as pass with it into a settling chamber for the separation of the liquid from the solids, and the conveyance from the settling chamber of the real liquid manure to a suitably constructed storage chamber from which it can be removed when required for disposal on the land.

The removal of the solids from the animal house should be done as frequently as possible, from stables and byres at least twice a day and from piggeries at least once. The manure or dung pit should

be placed as far from the buildings as can be arranged, but consideration must be given to the labour involved. It must not be placed near to a dairy or milk store or in close proximity to the farmhouse itself, nor in the line of prevailing winds. The bottom of the pit should be of cement concrete, and it should be surrounded by a wall about four feet high with a break sufficiently wide to admit a farm cart with ease. A corrugated iron roof will improve the value of the manure by preventing dilution with excessive rain. If the roof is placed too low the manure will get too hot and spoil.

The liquids from all the animal buildings should be brought to converge at one point if possible. At the point of convergence the pipes should meet in an inspection chamber fitted with half pipes. All drains should be laid so as to cause as little check as possible to the even flow of the liquid. From this chamber one pipe should carry the liquid to the settling chamber. The settling chamber should be constructed of cement concrete throughout, or with a cement concrete floor and walls of brick faced with cement. It should be divided into two parts by a vertical plate passing from the top down to the bottom and fitted into grooves at the sides and bottom. The plate should be perforated so as to let the liquids pass through to the distal side of the tank and retain the solids on the inlet side. The outlet pipe leading to the liquid manure storage tank should be bent down so as to dip into the liquid, thus forming a seal to prevent the backflow of gases from the storage tank, thereby conserving the ammonia in the liquid manure. The storage tank must be placed at a point suitable for the collection of the liquid and its distribution to all parts of the farm; close proximity to a roadway is therefore desirable. Like the manure pit its location must be such as not to create a nuisance.

The size of the tank will naturally depend upon the size of the farm and the number of animals kept. The Ministry of Agriculture and Fisheries suggests an allowance of 12 to 15 cubic feet of tank capacity per head of cattle. The following table of dimensions is taken from a leaflet of the Ministry.* In the case of larger tanks alternate measurements are given for deep or shallow tanks.

* F.P. 449/SI.

Table giving Dimensions of Liquid Manure Tanks.

Head of Stock.	Tank Capacity. Cub. ft.	Gallons.	Tank Dimensions. Rectangular. Length. ft.	Width. ft.	Depth. ft.	in.		Circular. Depth. ft.	in.	Diameter. ft.
10	150	937	8 ×	5 ×	3	9		5	4 ×	6
15	225	1400	10 ×	5 ×	4	6		6	0 ×	7
20	300	1870	10 ×	5 ×	6	0		6	0 ×	8
30	450	2720	12 ×	5 ×	7	6		7	0 ×	9
50	750	4680	12 ×	10 ×	6	3	deep	9	6 ×	10
			18 ×	12 ×	3	6	shallow	4	3 ×	15
75	1125	7000	12 ×	10 ×	9	6	deep	10	0 ×	12
			20 ×	12 ×	4	9	shallow	4	6 ×	18
100	1500	9370	15 ×	10 ×	10	0	deep	8	6 ×	15
			20 ×	15 ×	5	0	shallow	4	9 ×	20

The tank must be made of impervious material throughout, and the bottom should be constructed of reinforced concrete. The sides may be built of concrete reinforced like the bottom, or be brick-built and faced inside with a good coating of cement. Absolute gas-tightness is an essential of all liquid manure tanks so as to conserve the ammonia. The top must be fitted with a manhole, the cover of which should be of iron with a tongue to fit into a groove in the frame, which should be filled with grease so as to form a gas-tight joint. The pump for extracting the liquid should be as simple as possible, coupled with efficiency, and should be so fitted that no escape of gas is possible.

THE DISPOSAL OF SEWAGE.—There are two methods of disposing of human excreta, the *Dry* and the *Wet*.

Dry Method.—With this method the excreta is deposited into some form of privy or midden or into a pail. For several reasons the dry or *conservancy* method is unsuitable for towns, but in the country and for isolated houses it is a useful and safe procedure. Privies should be placed well away from a dwelling-house, cow byre or dairy, and not be so located that pollution of water supplies might be possible. They should be constructed of impervious material, such as bricks lined with cement, and should not be too large. At their best they are undesirable.

Pails are not objectionable if kept under proper conditions. Each excretal deposit should be covered with earth or ashes and the pail should be emptied daily, the contents being buried under the soil.

The Wet Method.—With the wet method the sewage and foul water is carried by water through pipes or sewers to an outfall

where it is disposed of in one of several ways. The sewage system of a town may be a *combined* system or a *separate* system. The former means that all the waste water and sewage, including excreta, slop water, trade effluents and rain water, are conveyed in one channel. With the separate system rain and surface water are carried separate from the remainder or true sewage. The latter is the preferable method.

Sewage may be disposed of as follows :—

Discharge into the Sea.—The outlet pipe must be carried well out so that the outlet is always under water whatever the state of the tide; the outlet end is fitted with a valve flap to prevent the tide from flowing up.

Discharge into Rivers.—Under the Rivers Pollution Prevention Act of 1876 (which see) no solid or liquid sewage matter may be allowed to flow into a stream unless the flow was practised before 1876, and then the persons responsible must take the best and most practical means to make the sewage harmless. Nevertheless many country houses discharge crude sewage direct into adjacent streams.

Discharge into Cesspools.—A common method of disposal of house sewage in the country is to drain it into cesspools. A cesspool is a pit lined with brick, which may or may not be faced with cement. If not made impervious with cement, the liquid drains away into the surrounding soil and only the solids remain behind for subsequent removal when the pit becomes full. In isolated places where the subsoil is suitable the porous cesspool may be used with advantage, but it must be so placed that there is no risk of contaminating the water supply. The distance it should be placed from a well or other water supply depends upon the nature of the subsoil, and no arbitrary distance can be defined.

The disposal of town sewage, where discharge into the sea is not practicable, offers many difficulties and various methods are adopted.

Surface or *Broad Irrigation* or *Sewage Farming.*—For the sewage farming method of disposal about 1 acre per 100 of population is required. The land must have a slight gradient and a suitable light subsoil. Clay is unsuitable. It is divided by narrow shallow channels through which sewage is conveyed so that each part of the land gets saturated in rotation. The sewage percolates through the soil, and the affluent is carried away by subsoil drains, which are laid about 6 feet deep, to discharge into a river or other outfall. The land is used for the cultivation of grass, roots or cabbages, and large crops are grown, though often of a rank nature. If too much sewage is put on the land it becomes " sewage sick."

Sewage farms require careful management, and frost and heavy or continuous rainfall interfere with the satisfactory working. The crops are most commonly used for feeding to cattle and pigs.

Intermittent Downward Filtration.—With this system the sewage is conveyed over ground so prepared that it acts as a filter. Sand, chalk or clay soils are unsuitable, and a porous loam or marl containing hydrated ferrous oxide and alumina are the most suitable. As with the sewage farming method, tile-pipes are laid about 6 feet below the surface to carry off the effluent. Sections of the land, or filter-beds, are saturated in turn with the sewage, thus the term *intermittent*.

Crops are grown on the land much in the same way as in sewage farming, but they are of secondary importance. By filtration the coarser material is arrested and the nitrifying organisms in the soil convert the ammonia into nitrites and nitrates. Aeration of the soil also oxidises the organic matter, and if the soil is suitable there is a chemical action on the sewage. The amount of land required for the filter-beds is about 1 acre per 1000 head of population when crude sewage is filtered and about 1 acre per 5000 if a proportion of the suspended matter is previously removed. This method is very efficacious, but the original cost of preparing the beds is large and suitable ground is difficult to obtain.

Precipitation or *Chemical Treatment.*—This process consists of the precipitation of the suspended matter by the addition of precipitants such as lime, lime and alum, or lime and sulphate of iron, or magnesium chloride. Lime by itself is unsatisfactory as such a large quantity has to be used and the resultant effluent is strongly alkaline. Large quantities of deposit or *sludge* are produced by this method of treating sewage, which is pressed through filters to remove the water, and the material is then sold as native guano for manure.

Electrolytic Method.—With this method the sewage flows past cast-iron plates, through which is passed an electric current. The chlorides in the water and sewage are split up into chlorine and oxygen. Hypochlorous acid is formed which oxidises the organic matter. Hydrated ferrous oxide is also formed from the iron plates, which oxidises as well as precipitates the organic matter.

Bacteriolytic or *Biologic Method.*—The object of this method is to bring about self-destruction of the sewage by favouring the action of bacteria. The anærobic organisms digest and liquefy the solid organic matter, producing soluble nitrogenous compounds, fatty acids, ammonia and other gases. The ærobic organisms cause the formation of nitrites and nitrates, carbon dioxide and water.

SECTION IV.

AIR AND VENTILATION.

A PLENTIFUL supply of pure air is the first essential for health, and the fact that it is made impure by animals, and that the processes of contamination if allowed to go on unchecked would ultimately render the air incapable of supporting life, makes it necessary that the hygienist should have a clear conception of (1) the impurities that exist in the air; (2) how they accumulate; (3) to what degree they can be tolerated; and (4) how they may be rectified. So long as animals are scattered and live a free and open-air existence the pollution they cause is of no practical moment. When animal life is crowded in a restricted area, with restriction of natural purifying means, the composition and character of the air becomes changed from the normal state to one which, if not necessarily fatal to life, may at least appreciably reduce vitality. The more confined the space in proportion to the animal life contained within it, the more serious is the pollution and the more rapidly does it take place.

Pure air is a mechanical mixture of various gases holding in suspension a quantity of water vapour. Such uncontaminated air has the following composition by volume:—

Oxygen	20·94 per cent.
Carbon dioxide	0·03 to 0·035
Nitrogen	78·09
Argon	0·94

Helium, krypton, neon, &c., traces.

There are also traces of ammonia, ozone, nitric acid, free hydrogen and methane. On an average air also contains about 1·4 per cent. of moisture.

Pure air is never found in the vicinity of animals or people, because by them the proportions of its normal constituents are altered and foreign matters, some of which may be harmful, are added to it. The normal physiological processes cause a reduction in the amount of oxygen, an increase in the carbon dioxide and methane and an alteration in the physical character of the air by increasing its moisture and temperature. The combustion of coal and other fuel, the decomposition of animal and vegetable matter,

the combustion of illuminating and heating gases and the various trade and manufacturing processes all take a part in rendering the air less pure. Factories discharge various gases and substances in suspension into the atmosphere, some of these may be deleterious and some harmless. Chemical works add sulphurous acid, sulphuretted hydrogen and other gases, but the discharge of such gases into the atmosphere is regulated by the Alkali Acts, which require that, in the case of hydrochloric acid gas, not more than one-fifth of a grain per cubic foot of air, smoke, or chimney gas may pass out into the atmosphere. Of acid gases of sulphur and nitrogen, not more than the equivalent of four grains of sulphuric anhydride per cubic foot of air must be discharged into the atmosphere. Free ammonia is found in the air of badly constructed and badly ventilated animal houses, and results from the decomposition of urea. Under good hygienic conditions and with good stable management it should not be present in appreciable amount. The evaporation of foul water from cess-pits and stagnant pools may add gaseous products to the air.

At each respiratory act the inspired air loses about 4½ per cent. of its oxygen and gains 4 per cent. of carbon dioxide. The nitrogen and other gases remain substantially the same. Thus the composition of expired air is:—Oxygen, 16·4, carbon dioxide, 4·1, nitrogen, 78·09, and argon, &c., 0·94 per cent. Of great importance is the physical change, as after inspiration the air is raised to the temperature of the animal body and is saturated with moisture. This fact is clearly seen on cold days when condensation takes place as the warm, moist exhalations come in contact with the colder and drier atmosphere. As air becomes warmed expansion takes place, therefore the air of expiration has a greater volume than that of inspiration. This fact is the basis of all systems of natural ventilation.

Oxygen Decrease.—The nitrogen and other inert gases may be neglected so far as a study of air pollution is necessary, since they play no part in rendering the air harmful to either mankind or animals. There is reason to believe that oxygen, though it is decreased over 4 per cent. at each respiration and retained in the tissues, may also be regarded as a negligible factor among the many which either singly or by their combined effects may be deleterious. It is known that the amount of oxygen may be reduced to less than 17 per cent. before its diminution becomes harmful to man. Air containing so low a proportion is unable to support combustion. In greatly over-crowded rooms it is said rarely to fall below 20 per cent. While it is now safe to assume that the actual diminution in the

amount of available oxygen is of no practical importance, men and animals may suffer from oxygen starvation in badly ventilated places owing to the heat and humidity which affect adversely the absorption of this gas by the tissues. The amount of oxygen in the air is also reduced by the combustion of gas and other illuminants (except electric light) and by the fermentation and oxidation of organic matter. Stale food, dirt and all substances undergoing putrefaction withdraw oxygen from the air and liberate cther gases in its stead.

Carbon Dioxide Increase.—Much importance was at one time attached to the amount of this gas in inhabited places. It was considered to be distinctly deleterious to health if present in anything but a very small percentage above the normal, but undoubtedly more attention has been paid to it than was called for.

The increase in the amount of carbon dioxide in the air resulting from metabolism occurs *pari passu* with other changes such as decrease of oxygen and increase of organic matter, heat and humidity, and as quantitatively it is estimated with comparative ease it serves as a useful index of atmospheric pollution. Such, no doubt, is its chief significance.

If it is possible to ascertain what is the average amount of carbonic acid gas excreted by each species of domestic animal during any given period, when housed under normal conditions, then one can form a fair estimate of the rate of general pollution. Supposing that by experiment and careful observation under practical conditions it is determined what is the maximum degree of pollution that may be permitted in buildings, having regard to the health of the animals contained therein, there should be no difficulty in calculating the volume of fresh air that must be admitted in order that the vitiation does not exceed such limit as may be set.

The amount of carbon dioxide excreted during normal metabolism by an average man while in a state of comparative quiescence is $0 \cdot 6$ cubic foot per hour; a large man undoubtedly produces more than this, and there is also an increase with active work and during the eating and digestion of food. The hygienist concerned with the health of people has taken this as an average figure from which to calculate the rate of vitiation and consequently the amount of repurifying air that is required.

Estimates given of the CO_2 excretion by the larger animals, horses and cattle, differ considerably, which is to be expected as the weight and surface area of the various types of horses and cattle vary greatly. Furthermore, the amount of food consumed, and to a certain extent its nature, have an important effect on the gaseous

excretion. The rate of heat loss and of CO_2 excretion depend upon the proportion between the surface of the body and its mass or weight. Thus, weight for weight, large animals will produce less carbon dioxide than small ones.

The following tables of Munk and of Colin show what these investigators found to be the CO_2 excretion during a twenty-four hour period for the various domestic animals.*

MUNK'S TABLE.

Animal.	Live Weight in Pounds.	Carbon Dioxide Excreted.	Oxygen Absorbed.
Horse . . .	990	171.9 c. ft.	150.8 c. ft.
Ox . . .	1320	196.0 „	196.5 „
Sheep . . .	154	20.5 „	21.0 „
Dog . . .	33	7.9 „	10.5 „

COLIN'S TABLE.

Animal.	Live Weight in Pounds.	Carbon Dioxide Excreted.	Oxygen Absorbed.
Horse . . .	990	151.0 c. ft.	150.0 c. ft.
Ox . . .	990	122.3 „	122.0 „
Ass . . .	330	50.4 „	50.0 „
Pig . . .	165	55.1 „	29.7 „
Sheep . . .	99	22.6 „	29.3 „
Dog . . .	44	10.3 „	14.0 „

Zuntz and Lehmann† give the average CO_2 excretion per hour for a horse weighing about 1000 lbs., that is a horse of the cab or vanner type, as 3 cubic feet per hour, and this estimate is now considered to be sufficiently accurate for all practical purposes. It has been used for many years as the figure from which to calculate the amount of fresh air required by horses of this size.‡ It must, however, be fully realised that 3 cubic feet is not a fixed and definite quantity applicable to all sizes of horses and consuming

* *Veterinary Physiology,* F. Smith, 1912.

† *Veterinary Physiology,* F. Smith, 1912.

‡ *Veterinary Hygiene,* F. Smith, 3rd Ed., 1905.

different amounts of food, but rather that it is subject to variation in either direction.

From the experiments carried out in America by Armsby and Fries for the purpose of determining the net energy values of foods, valuable data concerning the gaseous excretion by cattle of varying weights and consuming different quantities of food are available. The following selections* are given not only because they are recent findings, but also for the purpose of emphasising the difficulty of giving an average figure that will be even approximately correct for all classes of cattle.

Table showing the carbon dioxide excretion from steers on maintenance and fattening diets :—

Nature of Diet.	Live Weight of Steer.		CO_2 Excreted in 24 hours.	
	Kilos.	Pounds.	Grammes.	Cubic Feet
Maintenance .	195	429	2891	51.8
Fattening . .	280	616	3720	66.6
Maintenance .	410	902	3352	60.0
Fattening . .	410	902	5510	98.7
Maintenance .	520	1144	4054	72
Fattening . .	520	1144	6267	112
Maintenance .	490	1078	4634	83
Fattening . .	535	1177	7509	134
Maintenance .	642	1412	5894	106
Fattening . .	655	1441	9074	162

An examination of the above table will show that the quantity of carbon dioxide excreted by a steer weighing about 1000 lbs. while on a maintenance diet is 70 or 80 cubic feet for a twenty-four hour period, which is a similar amount to that excreted by horses of a like weight. The table shows that cattle weighing thirteen hundredweight will excrete about 6·5 cubic feet of CO_2 per hour when on a fattening diet; and as it seems reasonable to suppose that there is a similarity between the gaseous excretion of heavy horses and heavy cattle as there is between the lighter animals, it is not improbable that heavy draught horses weighing 14 or 15 hundredweight will discharge into the air at least 6 cubic feet of CO_2 per hour when they are on a full productive diet.

A fattening pig or sow will discharge approximately 1 · 5 cubic

* Kindly supplied by Professor Armsby.

feet, a sheep, 1 cubic foot, and a dog of about 50 lbs. 0·3 cubic foot.

The amount of carbon dioxide in a building is increased by the combustion of coal-gas and oil for illuminating purposes. An ordinary gas jet produces about 3 cubic feet of CO_2 per hour, and in addition some water vapour. An incandescent burner consumes relatively less gas and therefore produces correspondingly less heat and fewer impurities. Oil lamps such as are used in byres and stables add to the air combustion products approximately equal to those of an ordinary gas burner.

The Significance of Carbon Dioxide.—The air of inhabited places always contains an amount of carbon dioxide greater than that found in pure outside air. Experimental evidence is to the effect that no harm results to man until it accumulates to about 1 per cent. of the atmosphere, or nearly 40 times the quantity found in normal air.

Though this amount may be found occasionally in very foul rooms, it is exceptional for it to be present in greater quantity than 0·4 per cent. Baskerville found the general average in American schoolrooms to be 0·09 per cent.

Some interesting and valuable data concerning the percentage of carbon dioxide found in cow byres are supplied from the experiments initiated by the late John Spier and carried on by Dr. Douglas and Professor Hendrick* for the purpose of determining the degree of pollution of the air in commercial byres, and, at the same time, to study the influence of temperature on milk yield. It is certain that the byres used were above the average commercial standard both as regards construction and cleanliness. The average CO_2 content of sixteen byres was recorded as 0·248 per cent., and for two exceptionally well-ventilated buildings the average was found to be 0·11 per cent. The minimum amount found in what may be regarded as a "model" byre was 0·05 per cent., and the maximum in the same byre 0·17 per cent. These experiments were conducted during the winter months from December to March, that is during the period when it is most difficult to keep byres sufficiently well ventilated and at the same time warm. The CO_2 was found in greatest amount in the evening a short time after the byres were closed for the night. Hendrick attributes this to the fact that the digestive system of cows is working harder during the evening a short time after feeding than in the early morning when they have been resting, and we know that gaseous exchange varies with intensity of metabolism.

* *Trans. High. and Agric. Soc.*, 1909, 1911, 1913.

Mackenzie and Russel* investigated the condition of the air in two poultry houses of different types and found that there was present 0·067 and 0·082 per cent. of CO_2, and that the birds remained healthy in both houses. They therefore assume that the air of poultry houses may contain with safety from 0·07 to 0·08 per cent. of CO_2, and consider that 0·09 per cent. should be the maximum amount that should be allowed. Reiset and Regnault's experiments showed that poultry take up about 0·03 cubic foot of oxygen per hour and give out about the same quantity of CO_2. Richet's trials at a later date, 1890, gave approximately the same results.

Owing to the great importance of the maintenance of the health of workers in factories and of children in schoolrooms, hygienists have studied closely the air conditions in factories and dwellings and, *inter alia,* have determined what they consider to be the maximum amount of CO_2 that should be permitted. By the Cotton Cloth Factories (Amendment) Act, 1887, the amount of CO_2 in these factories is not allowed to be greater than 0·09 per cent. of the atmosphere. Later, in 1902, Haldane and Osborne recommended that the maximum should be 0·12 per cent. during the day or when artificial illumination was by electricity, and that 0·20 per cent. should not be exceeded at night when the illuminant was gas or oil.

It does not appear to be practicable in the case of schools and workshops to keep the air as pure as theoretically would seem advisable.

It is obviously impossible, however good any system of ventilation may be, to maintain the air in a building of the same composition either chemically or physically as pure outside air, therefore a certain amount of general impurity is conceded as permissible. The limit of this impurity is indicated when the air is found to contain an additional 0·02 per cent. of carbon dioxide to that present in pure air, viz., 0·03 per cent. Theoretically, then, the air in any building housing either animals or men should not contain more than 0·05 per cent. of CO_2, which quantity is composed of two fractions, 0·03 per cent. normally present (and therefore not an "impurity" as it is frequently called) and 0·02 per cent. a *permissible impurity.*

With the veterinary hygienist rests the responsibility of deciding what degree of pollution should be permitted in animal buildings. If an unnecessarily high standard be set it is not likely to be accepted by those financially interested; on the other hand, if the standard

* *Trans. High. and Agric. Soc.,* 1908.

be too low the health of the animals will suffer and unhealthy cows cannot produce healthy milk. This being so, no degree of vitiation ought to be permitted that will prejudice the health of the confined animals, whatever the financial problem might be.

Notwithstanding that Hendrick did once find a cow byre containing no greater amount of CO_2 than that which has been defined above as permissible, the author is inclined to think that this standard is in general almost unattainable and, in the case of herbivorous animals, hardly necessary. It is here suggested that the limit of CO_2 impurity should be 0·06 per cent. for all animal habitations, that is to say, the total proportion of CO_2 in the air should not exceed 0·09 per cent.

Undoubtedly the chief significance of carbon dioxide in a building is the general indication it may afford of the efficiency of the ventilation. In habitations devoid of artificial heating, excessive humidity and high temperature are the chief evils; both are concomitant with air stagnation. Air stagnation in an inhabited building necessarily means an increase in the proportion of CO_2, and though it is rather doubtful in the case of herbivorous animals if the percentage of this gas really affords an exact indication of the degree of vitiation, it is certain that if it is not present in greater amount than 0·05 per cent. the state of the atmosphere will be all that could be wished for. It is believed that if 0·09 per cent. be present no harm will result, and that neither temperature nor humidity will be greater than is desirable. Nevertheless it is an indisputable fact that the nearer to natural conditions animals can be kept the healthier will they be. There is also unquestionable evidence that horses can live and thrive in open stables in this country throughout the winter, being merely sheltered from wind and rain. Under such open-air conditions infectious diseases are rare, and when they do occur are of a benign type.

INCREASE OF HEAT AND HUMIDITY.—When a number of animals is confined in a building where inadequate provision is made for ventilation, the temperature of the air rises from the heat given off from their bodies. As the temperature of the air increases by the accumulation of this thrown-off body heat, so is there an increase in the amount of CO_2, organic matter and water vapour, and a corresponding decrease in the amount of available oxygen.

The difference between the temperature inside and outside an animal building, where no artificial heating is employed, is a good guide to the general condition of the air. If in the winter the difference is not great then it may rightly be assumed that the pollution is not excessive and, on the contrary, if the inside temperature

is much above that outside, then the vitiation must be correspondingly great.

A great many cowkeepers and stablemen believe that it is necessary to maintain a high temperature in a byre or stable, and as, under ordinary conditions, it is economically impossible to obtain this heat-increase artificially they proceed to obtain it by restricting the ventilation to prevent the escape of waste body heat, so that literally the animals are self-warmers. This pernicious belief is most prevalent among city dairymen, and it is in city byres that the attendant evils are most pronounced. In spite of scientific proof to the contrary many dairymen persistently hold to their opinion, and it is nothing more than an opinion, that warmth is essential for milk production. The strongest argument that is brought forward in support of this contention is that when a sudden drop in the temperature occurs, as, for instance, may happen in the night with a shift of wind, the yield of milk on the ensuing morning is sometimes less than it would have been had the temperature remained at its higher level. It cannot be denied that such may be the case, but the reason is not that the air is cold but that cows kept too warm, and especially in an atmosphere holding too much moisture, are especially susceptible to the chilling effect of fresh, cold air.

Douglas, in summarising the results of the experiments carried out by the Highland and Agricultural Society (Transactions, 1911), points out that the production of milk can be carried on at least as profitably in byres ventilated so that the temperature is kept down to 50° F. as in those where the temperature is kept ten degrees higher at the expense of ventilation. A temperature of 50° F. should be the maximum one allowed in cow byres in this country during the winter, and there is no reason why it should not be permitted to fall considerably lower. Care should be taken to see that byres are kept cool in the autumn and early winter so that the animals retain their winter coats and be in a condition to withstand colder air as the cold season advances.

When horses and cattle are housed in warm quarters, or, in the case of the former, if heavily rugged, they do not carry a warm winter coat since Nature finds that one is not required. Cows bought in from farms and put into badly ventilated and warm byres soon lose their long winter coats, a loss which they greatly feel when turned out in the early spring.

It is no more necessary to maintain a high temperature in stables for horses than for cows or other domestic animals. When it is advisable to clip or half-clip working horses one or two rugs

may be supplied. Given a warm, comfortable and dry bed, a sufficiency of food and a rug or two if necessary, the temperature of the stable may be ignored however low it may fall, provided that wind is shut off. Under these conditions and with free ventilation cold air can do no harm. What does harm is cold air so entering a stable or byre as to cause a draught.

It is impossible to raise the temperature in animal quarters by restricting the ventilation without at the same time causing an increase in both the absolute and relative humidity, as animals are continually discharging moisture from their bodies into the atmosphere, and there is always a potential source of moisture on the floor in urine and in the fæces. If the ventilation is inefficient the air becomes surcharged with moisture and the relative humidity raised. For mankind it is considered that the optimum degree of humidity lies between 70 and 80 per cent. of the maximum that it could hold at any temperature. This probably applies equally to animals. Spiers,* when investigating during the winter months the influence of temperature on milk yield, found that in a set of freely ventilated byres the relative humidity ranged 80 to 94 per cent., and that in another set of buildings where the ventilation was restricted it ranged from 85 to 96 per cent., the average for the former was 88·3 and for the latter 92·7 per cent. Undoubtedly in many byres the air is practically saturated with moisture.

The atmosphere in a building heavily laden with moisture is stagnant and oppressive, and it holds a greater amount of organic matter than does drier air.

The effect on the animal body of an excessively humid atmosphere is the prevention of free respiratory and cutaneous outlet of waste heat and products of metabolism. Under such conditions health is impossible.

When the temperature of the air in a building is appreciably lower than that of the animals, there is a loss of body heat by radiation and convection. This loss lessens as the temperatures approximate. Evaporation of moisture from the body can only take place when the surrounding atmosphere is unsaturated.

The fatter the animal or the more intensively it is fed, the greater is the metabolism and the greater need for facility to eliminate waste products. The fatter the animal the less able is it to withstand high temperatures as fat is a bad conductor of heat.

Warmth with humidity is above all conditions to be avoided; unquestionably this combination is the greatest evil in badly ventilated animal houses.

* *Trans. High. and Agric. Soc.*, 1909.

Organic and Suspended Matter.—A considerable amount of organic and particulate matter is found in the air of animal quarters. It originates from pulmonary exhalations, from cuticular debris, from dust and pollen of foods, from desiccated fæces and from dust and dirt brought in from the outside. Micro-organisms, too, are found in varying quantities; these may or may not be of hygienic importance. In cow byres they may be in sufficient numbers as to cause serious pollution of the milk as it is gathered to the cans, and they may be pathogenic to the animals.

At one time it was thought that the organic matter was responsible for the baneful effects caused by animal-life vitiation, and attempts were made to show that expired air contains a specific poison. It seems to be definitely settled now that "organic matter," *per se,* is of but minor importance.

The atmosphere in a badly ventilated room inhabited by people has a peculiar and very disagreeable odour which is derived from the organic matter given off from the body. Dr. de Chaumont considered that the smell of vitiated air could serve as a fairly reliable index of the degree of pollution, and he compiled a table for the purpose of estimating by the sense of smell the amount of CO_2 in the air. This table is given on page 107.

Whatever value this test may have with regard to human habitations, it is certainly of very doubtful utility in animal buildings. In cow byres the air may contain a comparatively high proportion of CO_2 and yet smell fresh, provided that the drainage is good and the place kept clean.

Mackenzie and Russel* from their investigations in the air pollution of poultry houses concluded that "the smell of a house is no guide to the purity of its atmosphere, but is due rather to the droppings: a house may smell fairly sweet and yet contain an excessive amount of carbonic acid."

Each species of animal has an odour peculiar to itself which is imparted to the surrounding atmosphere. Apart from the fæcal stench of foul pig-styes, no air contaminated by animals can smell so foul as that of an over-crowded, unventilated room inhabited by uncleanly persons.

The Bad Effects of Impure Air. — The result of keeping animals or people in an impure atmosphere is not always obvious at first. A badly ventilated animal house is an insidious danger. The bad effects that follow the confinement of animals in a foul atmosphere are the result of an accumulation of forces. At some time, possibly remote, there becomes evident a lowered vitality, a feeble

* *Trans. High. and Agric. Soc.,* 1908.

resistance to disease, especially that of an infectious nature, a protracted and often unsatisfactory recovery from illness, and an inability to produce strong and vigorous offspring.

Not only is the natural resistance to disease lowered, but the air itself in a badly ventilated building may contain large numbers of pathogenic bacteria. The contagium of influenza, pneumonia, glanders and tuberculosis, to name only a few diseases, has less chance to remain virile and to find receptive hosts in a well ventilated, dry and cool building than in one in which the air is constantly foul, warm and moist. Anæmia in the human subject is a well recognised sequence to habitual confinement in badly ventilated rooms. Whether dairy cattle confined month after month in equally adverse conditions suffer in a similar manner has not been clearly demonstrated, but it is known that poultry do. Mackenzie and Russel, who have carefully studied the hygienic housing of these birds, especially remark on the anæmic look of birds kept in close houses, and say that they are more liable to tuberculosis and diphtheretic roup, and that egg production is not so prolific during the winter months as when the houses are suitably built and ventilated. They quote Gilbert's Canadian experiments which showed that chickens hatched from eggs laid by birds living in ill-ventilated houses are delicate.

VENTILATION.

The problem of ventilation is one that arises owing to the necessity of housing animals in order to protect them from inclement weather, to provide for them a convenient resting-place at night, and for economy in attendance.

In order to rectify the pollution that takes place in an animal house it is necessary to supply to the building an amount of fresh air proportionate with the rate and degree of such pollution. It is therefore necessary to estimate what amount of fresh air is required for each species of animal that is to be kept in confinement.

It is scarcely possible to supply too much fresh air as no atmosphere can be too pure, and it is essential for the health of the animals that the supply be not stinted, for if pollution goes on at a greater rate than purifying air is admitted, there must come a time when the air would be so foul as to be distinctly harmful.

In times past many persons responsible for the construction of animal houses approached the subject with the idea that a stable or byre must shut out fresh air in order that the temperature within might be kept high.

The modern view is to regard animal houses as necessary evils. If they cannot be dispensed with altogether, the only alternative is to make them as little " house-like " as possible, and to keep in mind that what is required is protection from rain, driving wind, excessive cold and damp and to provide facility for feeding and attendance.

THE AMOUNT OF AIR REQUIRED.—Ventilation has been described as " essentially a question of removing the curtain of heat which surrounds the body." It is no longer looked upon as a chemical or pulmonary problem, but as one which is physical and cutaneous. It is known that the mere fact of causing the hot foul air to circulate, as by electric fans, is sufficient to give at least a temporary relief (Hill), but for the improvement to be lasting the foul air must be replaced by pure air.

Since we know within a reasonable range of error the amount of CO_2 excreted hourly by the various domestic animals and have determined what may be regarded as a permissible addition to the air in a building, a very simple formula will show how much fresh air must be admitted every hour that there may be no accumulation of impurity.

De Chaumont's formula for calculating the amount of fresh air required is as follows :—

$$\frac{e}{p} \times 100 = d$$

where e is the amount in cubic feet of CO_2 excreted per hour, p is the percentage of permissible CO_2 impurity and d is the amount in cubic feet of fresh air required per hour.

It has been stated on a former page that if the air contains no more than 0·02 per cent. of CO_2 above the normal (0·03 per cent.) that a very satisfactory condition exists, but that 0·06 per cent., or a total of 0·09 per cent., may be allowed, although the latter should be regarded as the limit of impurity. The high standard should be the aim of all hygienists, but it is often necessary to effect a compromise between the two.

The formula to calculate the amount of fresh air required hourly by an average man will read :—

$$\frac{0.6}{0.02} \times 100 = 3000 \text{ cubic feet of air per hour ;}$$

since a man discharges 0·6 cubic foot of CO_2 per hour.

A horse of the cab or vanner type or a medium weight rider discharging approximately 3 cubic feet of CO_2 per hour will, under the high standard, require 15,000 cubic feet of air per hour, or,

where the limit of impurity is allowed, 5000 cubic feet per hour as is here shown :—

High standard :— . . $\frac{3}{0.02} \times 100 = 15{,}000$ cubic feet.

Low standard :— . . $\frac{3}{0.06} \times 100 = 5{,}000$ cubic feet.

If the quantity of carbon dioxide in the air is determined by analysis, it is possible by the use of this formula to calculate the amount of fresh air that has actually been supplied each hour. Suppose, for instance, that the air in a cow byre is found to contain 0·20 per cent. of CO_2. Find the amount of fresh air admitted per hour, the cows being large animals on a full productive diet.

$$\frac{e}{p'} \times 100 = d'$$

where e = the amount of CO_2 discharged per hour; p' = the percentage of CO_2 found in the air less that normally present; and d' = the amount of air in cubic feet that has been supplied.

$$\frac{6}{(0.20 - 0.03)} \times 100 = 3530 \text{ cubic feet of air.}$$

On page 90 will be found a table giving the amount of air required hourly by the various domestic animals both for the high and low standard.

Cubic Space.—Necessary as it is to know how much fresh air must be supplied during a given time, it is equally important to appreciate how many times cows, horses, pigs, calves and other domestic animals can stand the air in their quarters being changed during the period.

According to the power of each to withstand frequent air change, that is their degree of susceptibility to draughts, will depend the amount of air-space to be allotted to each animal in a building. It is of the greatest importance to realise that each, let us say cab horse, must have 15,000 cubic feet of fresh air every hour if a high standard of purity is to be maintained, irrespective of the size of the stable. Supposing the cab horse to be confined in a small loose-box having a total capacity of 600 cubic feet, if 15,000 cubic feet of air is made to pass in and 15,000 feet made to pass out each hour, the entire air in the box would be changed 25 times each hour, or once in every 2½ minutes, a condition under which it would be unreasonable to expect any animal to live.

If, on the other hand, the horse be stabled in a box having a capacity of 2000 cubic feet, though the same amount of air would

have to be admitted per hour, the rate of exchange of the whole air in the box would be much slower, namely, seven and a half times per hour, or once in every eight minutes.

Experience has led to the belief that people in this country cannot stand the air being changed more frequently than three times per hour, and on this, accordingly, is based the 1000 cubic feet of space thought to be necessary for each adult person. A great deal depends, however, on the cooling power of the air.

Experience has shown likewise that horses and cattle can stand the air being changed as frequently as nine times in the hour without any discomfort or ill effects. Mackenzie and Russel are of the opinion that fowls should not be expected to contend with a more frequent change than four times each hour. It is probable that pigs, dogs, calves and sheep can stand the air being changed as frequently as can horses and cattle. In accordance with this conception the table here appended has been compiled.

Table showing the amount of fresh air required each hour and the necessary cubic space per animal :—

Animal.	Cubic feet of CO_2 excreted per hour.	Cubic feet of *air* required per hour if total CO_2 is not to exceed :—		Cubic feet of *air space* required per head where total CO_2 is not to exceed :—	
		0.05 per cent.	0.09 per cent.	0.05 per cent.	0.09 per cent.
Large cows, fat cattle, heavy horses	6	30,000	10,000	3,000	1,100
Medium horses, medium cattle	3	15,000	5,000	1,600	550
Large pig or sow	1.5	7,500	2,500	830	270
Sheep	1	5,000	1,600	550	180
Dog	0.3	1,500	500	160	55
Calf	1	5,000	1,600	550	180
Fowl	0.03	150	50	37	12
Man	0.6	3,000	1,000	1,000	330

General Principles of Ventilation.—Ventilation means the methodical and uninterrupted exchange of foul for fresh air, so that at no time does atmospheric pollution in a building exceed a given standard.

If a number of cows are housed during the night in a byre the windows and ventilators of which are all closed, by the morning, when the cows are turned out to graze, the air in the byre will have become extremely foul. If after the animals have left the building

the windows, doors, ventilators and other apertures be thrown open, the foul air will soon be removed and be replaced by fresh air. On the return of the animals in the evening if the windows and other ventilators are again closed the air will once more become foul with excretory products.

The temporary purification of the building that was effected during the day is not an efficient substitute for true ventilation, but it is a method that is frequently adopted. Ventilation in the correct sense is a continuous, not an intermittent process.

Either natural or mechanical means may be employed to ventilate buildings. With the former method advantage is taken of the natural gas laws that govern the mixing and movement of the air, and though various contrivances may be used to facilitate the air exchange, the adoption of such devices does not constitute a mechanical or artificial system. A mechanical method of ventilation is one in which mechanical power is used to force air into or to draw air out of a building. In many buildings mechanical ventilation is introduced to aid a natural system.

NATURAL VENTILATION.—The two chief agents that keep the air pure and healthy are the movements of volumes of air of unequal temperature and the diffusion of gases of different densities. In a building the carbon dioxide and methane excreted by animals become diffused among the gases normally present; they do not concentrate around their source of production, but, by diffusion, are constantly diluted. The diffusion of gases is, therefore, an important aid toward ventilation by ensuring a certain uniformity in the composition of the air in a building. Chemical examinations of the air in stables and byres have shown that the percentage of CO_2 differs very little in the various sections of these buildings.

As ordinary building bricks are porous they permit of diffusion taking place through them, but such action is slow and ceases altogether if the brick walls are faced with cement or saturated with water. For practical purposes the actual passage of air into and from a building may be considered to depend upon the movements of volumes of air of different temperatures.

It has been stated in the section dealing with meteorology that a wind is the result of the upward passage into a higher altitude of heated and expanded air, the wind being a body of cooler air flowing in to fill the space thus created. Exactly the same process takes place in a building where there are animals whose body temperatures are greater than that of the air surrounding them. As the air becomes warmed it expands and rises to a higher level. If, therefore, provision is made for the escape of this heated

and expanded air it will pass out, and fresh, cool air will flow in to take its place.

The passage of air into and from a building is not solely dependent upon the degree to which the inside air is heated. Wind acting from the outside is a most powerful ventilating force, and its action is two-fold. It drives into a building through any suitable opening, mixes with and dilutes the vitiated air and forces it on and out through openings on the other or lee side. This is called the perflating action of the wind. The second power, and one of great importance, is the aspirating effect which is set up when wind passes across or through any opening. If wind passes in at one window and out at another on the opposite side it draws air from all points as it passes. Similarly, when it blows across an opening in the roof it aspirates air out of the building and so sets up other currents which flow in to fill the space formerly occupied by that which has escaped. As the atmosphere is very rarely still in this country there will nearly always be a certain movement of air into and from a building due to the action of the wind. A condition of absolute calm, however, does not necessarily imply that no air change will take place. As has been shown, so long as the temperature in a building is higher than that outside there will be a constant outward flow of hot air and an inward flow of cool air in exactly the same manner, though at a slower rate.

There is little difficulty in ventilating any animal house, even when not artificially heated, on either a cold, frosty day with complete absence of wind or on a warm day with an appreciable wind. The difficult days are those that are neither cold nor windy.

From what has been said, it will be clear that every system of ventilation is composed of two parts, provision for the escape of foul air and provision for the inlet of fresh air. The inflow of fresh air, especially in the absence of wind, depends largely upon the rate at which the foul air passes out. Each half of the system is dependent upon the other for the efficiency of the whole, and a potentially good inlet system is often restricted in efficacy by the inadequacy of the outlet.

Size of Inlets and Outlets.—Wind blowing at the rate of 3 miles per hour, which is practically a calm, will introduce into a building 110 cubic feet of air per hour for every square inch of inlet. Very rarely does the movement of air remain at such a low speed for any length of time, as the average velocity of the wind in this country is approximately 15 miles per hour. Provision for the inlet and outlet of air should be such as will permit satisfactory ventilation when the wind is scarcely perceptible. At least it is necessary

to make this full allowance when the building is situated in a sheltered position or is shut in by other buildings. For buildings on exposed sites and not sheltered from prevailing winds the size of both inlets and outlets may be less, especially if they are of a fixed type and not controllable.

As it is desirable to introduce into a stable for heavy horses, or into a byre for large milking cows, between 10,000 and 30,000 cubic feet of air per hour per head, the amount of actual inlet area per head will need to be 270 square inches for the higher and 90 square inches for the lower standard. For cab horses, light vanners and small dairy cattle the inlet per animal should be 136 square inches if the total CO_2 content is not to exceed 0·05 per cent. of the air, and 45 square inches if the lower standard or 0·09 per cent. of CO_2 is allowed.

The minimum inlet area to be allowed for any of the domestic animals can be readily ascertained by dividing the volume of air to be supplied hourly by the volume of air passing through each square inch of inlet when the wind is blowing at 3 miles per hour, *i.e.,* 110 cubic feet.

It is advisable that both inlets and outlets are made so that they can at least be partially closed when the wind is very strong and cold. It is, however, undeniable that excellent ventilating systems exist where neither inlets nor outlets can be altered, or where the outlets can be controlled and the inlets are fixed or *vice versa.*

In view of the greater tendency there is to close ventilators than to open them, it is strongly to be advised that at least a proportion of both inlets and outlets be of a fixed type. If the inlets and outlets are controllable they may be adjusted according to the force of the wind; thus with a wind blowing at 12 miles per hour the inlet area need only be one-quarter of that prescribed for the minimum provision.

A table is given on page 94 showing the inlet and outlet area that should be supplied for the various domesticated animals.

Relative Size of Inlets and Outlets.—Some are of the opinion that the total outlet area should be larger than the total inlet area on the supposition that heated and therefore expanded air occupies a greater volume than the colder incoming air, while others hold that the outlet area should be smaller than the inlet so as to prevent down-draught.

In practice it is found that if the total inlet and total outlet area are the same the result is quite satisfactory.

The table is therefore applicable for both inlets and outlets, *i.e.,* a large cow may be said to require a minimum inlet area of

90 square inches and also a minimum outlet area of 90 square inches.

Table showing the inlet and outlet capacity that should be allowed per animal with wind blowing at 3 miles per hour :—

Animal.	Square Inches of Inlet and also of Outlet required if total CO_2 content in the Air is not to exceed—	
	0.05 per cent.	0.09 per cent.
Large cows, fat cattle, and heavy horses,	270 sq. ins.	90 sq. ins.
Medium horses and medium cattle,	136 ,,	45 ,,
Large pig or sow,	68 ,,	23 ,,
Sheep,	45 ,,	15 ,,
Dog,	13 ,,	4 ,,
Calf,	45 ,,	15 ,,
Fowl,	1.3 ,,	0.4 ,,
Man,	27 ,,	9 ,,

METHODS OF VENTILATING BUILDINGS. — The customary and most efficient method of ventilating animal houses is to make provision for the escape of the foul air at the highest level possible, and to let the fresh air in at a lower level. This may be accomplished in a variety of ways by the use, for preference, of the most simple fittings such as will involve the least necessary attention. It should be borne in mind that in buildings with a loft or upper floor there is difficulty in securing ventilation at the roof, although, where possible, this difficulty should be overcome by the use of ventilating shafts between the byre or stable ceiling and the roof. These shafts may pass vertically to the roof ridge, or if there is objection to breaking up the floor space above, the shafts may be arranged to pass up the wall of the loft and follow the inner contour of the roof to the highest point. At their termination they require a cap, louvred outlet, or extraction cowl. In buildings with a loft where outlet shafts are for some reason considered to be inconvenient, the exchange of air must depend upon a system of cross ventilation.

There is no doubt that the best animal houses are those without an upper flat or hay loft and open to the roof. This gives good air-space and simplifies the ventilation.

INLETS.—These may be in any of the following forms :—*Wall windows, Tobin tubes, direct inlet pipes or boxes, air bricks or gratings* and *hit-and-miss windows.*

Windows.—Wall windows commonly serve the dual purpose of lighting and ventilating. In order to get the best results from the driving force, or perflating action of the wind, one window should be placed opposite another so that those on the weather side of the building act as inlets, and those on the lee side as outlets.

Ordinary sash windows such as are used in human dwellings are seldom seen in animal houses. The most common type, at least in stables, is the *Sherringham valve* or *hopper* window. This window is hinged at the bottom and opens downward as shown in figure 31. At the sides are guards to prevent down-draught.

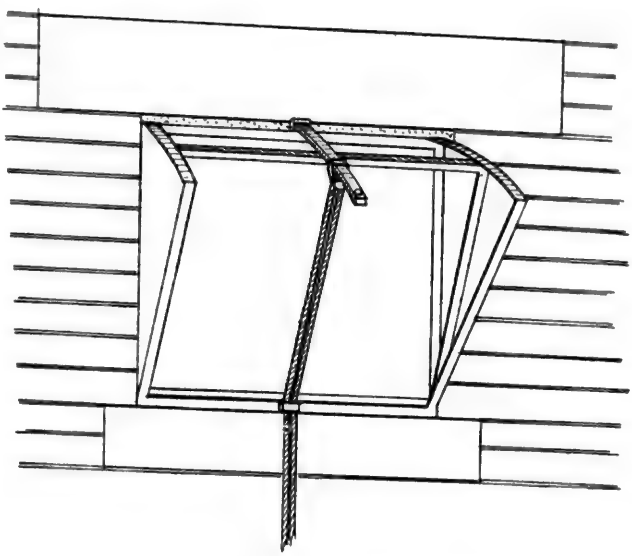


FIG. 31.—A Sherringham Valve or Hopper Window fitted with a quadrant.

The incoming air is thus directed upwards and spreads out fanwise before falling behind the animals. A great improvement on the existing type would be one that could be reversed when desired so that on very hot, close days, or for sick animals requiring an abundance of fresh air, or when the stables are empty during the day, the wind could be directed to fall downwards toward the manger and the floor of the stall. Sherringham valve windows should be under control so that they can be partly closed when necessary. A very good window that has been introduced for byres is one on the Sherringham valve principle that will lift right out of the framework, thus leaving a clear open space on hot days. If wall windows form the only ventilating means in a stable it must be remembered that only those on the weather side will act as inlets, then the *minimum* ventilating area of each window for each horse

or cow must be doubled. This, of course, applies to all forms of wall ventilators (see the table on page 94).

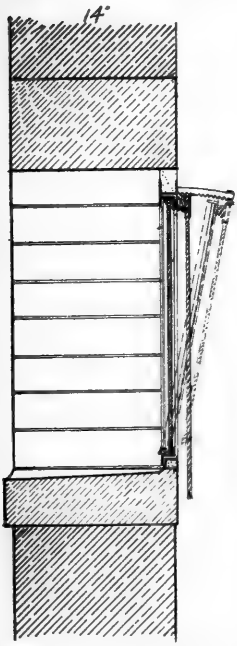


FIG. 32.—Section of a Hopper Window. The side guards are not shown.

Horizontally centre-pivoted windows (figure 33) are satisfactory in sheltered parts of a building, but are not so useful as the hopper type for exposed positions, because with a wind of any force the incoming air cannot be properly controlled, with the consequence that such windows are more often shut than open.

Tobin Tubes. — These are illustrated in figure 34. The air enters the tube at a low level outside the building and passes up a shaft, usually about 5 feet high, and then spreads out in the building without causing a draught. Though commonly used in human dwellings, public halls and the like, they are not generally adopted in animal buildings in this country, though they form an integral part of the King system as practised in America. They may be built in the wall or take the form of a box-shaft inside the building against the wall. The former method is better for animal buildings.

Direct Inlet Pipes or Boxes.—Very simple and effectual air in-

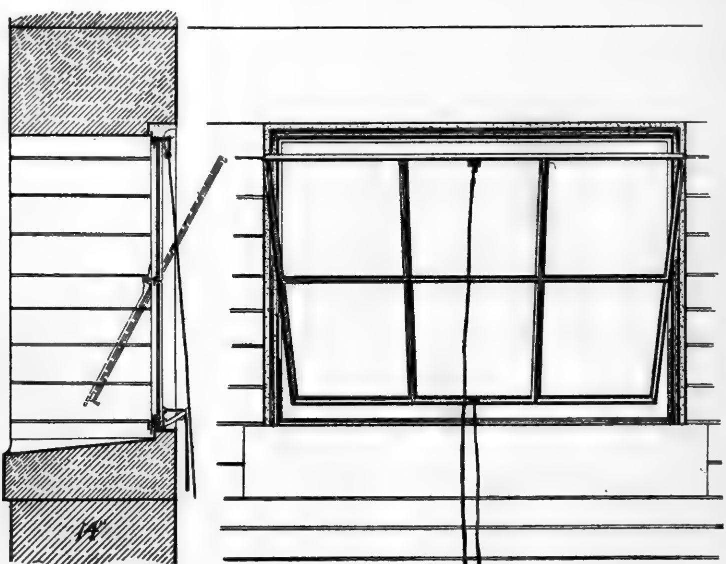


FIG. 33.—Centre-pivoted Window. Section and elevation.

lets for cow byres are ordinary fireclay drain pipes of about 4 inch diameter. These may be set level through the wall or placed at an angle that gives the incoming air an upward trend. In the west of Scotland it is the common custom to put one drain pipe between each pair of cows placed level and just above the food-trough. In some byres they are placed on a level with the cows' heads when they are standing. In some instances bent pipes are used in order to break the force of the incoming air. To those unaccustomed with this free method of ventilating byres it might appear to be too "draughty," but those dairymen who have adopted it speak very highly in its favour. Inlet boxes are sometimes fitted with regulating valves.

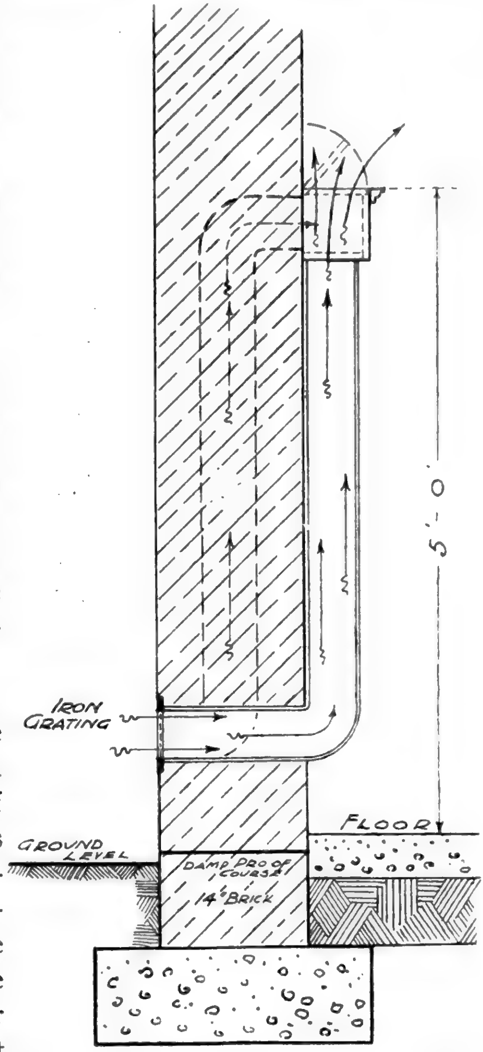


Fig. 34.—Tobin's Tube. A box containing a regulator is fitted at the top of the tube. The broken line shows the method of building a Tobin's tube inside a wall.

Air Bricks and Gratings.—Air bricks, as their name suggests, are perforated bricks for the admission of air. They are of various designs and sizes. Theoretically the inlet area is considered to be one-third of the brick face area. When the bricks have been in place for any length of time they get partly blocked with dust and cobwebs. Air bricks are usually placed in a continuous row along the wall just under the eaves; when large enough and in sufficient number they are useful adjuncts to the main ventilating system. *Jennings' bricks* are air bricks constructed so that the incoming air is given an upward trend. Another type, *Ellison's brick,* has the holes on the outside of the building smaller than those inside, so that as the air enters its

force is reduced. Galvanised cast-iron gratings and hit-and-miss gratings are sometimes used, but they are subject to the same objections as air bricks. Hit-and-miss gratings invariably get clogged with dust and corrosion and fail to work satisfactorily.

"Hit-and-Miss" Windows should not be confused with hit-and-miss gratings. The windows referred to are invariably constructed of wood and are either wholly for the purpose of admitting air by control, or partly for such and partly for lighting, any lighting part being filled in with glass. These windows probably derive their designation from being fitted into openings in the wall which were originally intended for ordinary windows. The hit-and-miss part consists of a board with slot perforations about three-quarters of an inch wide and of any length, the solid spaces between each slot may be about one inch or an inch and a half wide. Another board similarly slotted is fixed in grooves on the inside or outside (usually the former) in such manner that by the aid of a small knob screwed into the centre

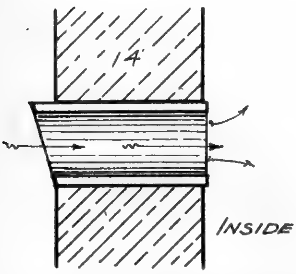


FIG. 35.—A Drain Pipe forming a direct air inlet.

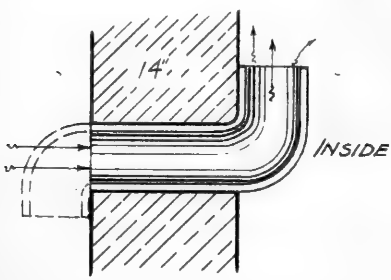


FIG. 36.—A Bent Pipe Air Inlet in which the air is directed upwards. An alternative method is to bend the pipe downwards on the outside of the building, as shown by the broken lines, in order to check the force of the incoming air.

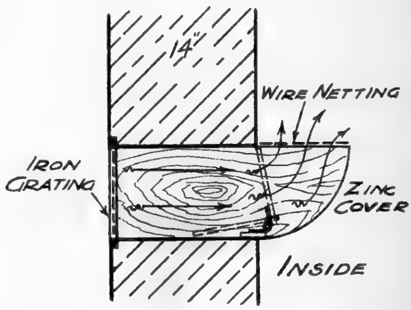


FIG. 37.—A Box Air Inlet fitted with a grating on the outside and a regulating valve on the inside. The incoming air is directed upwards.

of the sliding part it may be moved to regulate or entirely close the apertures. This type of ventilator cannot be recommended in consequence of its liability to jamb either by reason of wet, which causes the wood to swell, or in consequence of the invariable collection of dirt, dust and grain between the boards. In any case they are usually situated half-way up the wall of the stable or byre near the mid-stratum of contained air without any provision for turning the

draught off the animals. Consequently they are nearly always shut, being useless for either inlet or outlet.

Outlets.—The best possible form of outlet is an open ridge the full length of the building. By this provision the heated atmosphere escapes directly without being retarded by friction, its escape being hastened by the aspirating influence of any wind passing over the roof ridge. The physical explanation of this is clearly indicated by the arrows in figure 39.

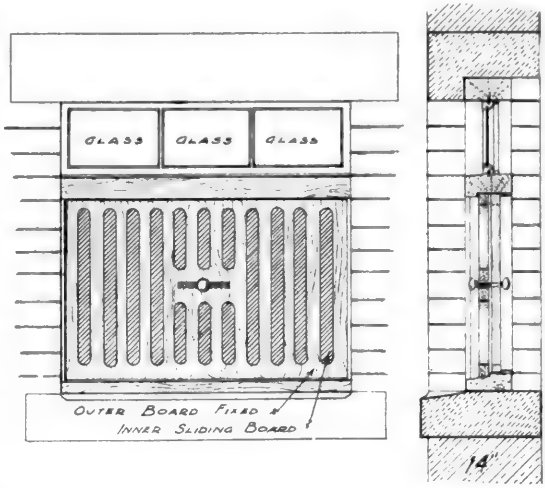


Fig. 38.—Elevation and section of a Hit-and-Miss Window.

It should be noted that the open ridge system is only possible in buildings without a loft. A permanently open ridge such as described has been successfully adopted for cow byres and piggeries, and found to be both cheap and efficient. The width of the opening will, of course, depend upon the height and size of the building. For an average piggery a width of 2 or 3 inches will be found to be sufficient. For byres and stables the width of open ridge must be calculated in accordance with the provisions laid down on page 94 for outlets required in proportion to accommodation of stock contained.

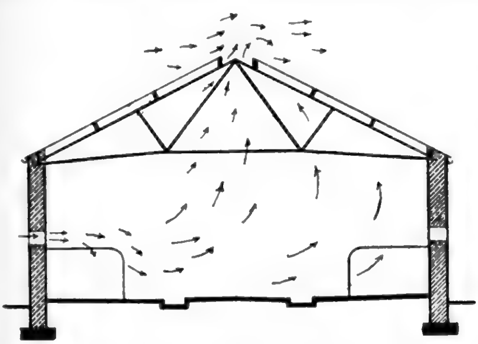


Fig. 39.—A Double Cow-shed with a permanently open ridge for the escape of foul air. The air inlets are drain pipes set at right angles to the wall just above the cows' heads.

*Findlay's System.**—Undoubtedly an improvement on permanently open ridge, especially for a building in an exposed position, is the method known as *Findlay's System.* It can be used for byres, stables or other animal houses that have an open roof, that is where there is not a room

* *Findlay's System of Byre Ventilation* (Registered), John Findlay, Springhill Farm, Baillieston, Glasgow.

or loft above the animals. The object of the system is to provide for the free escape of foul air at the most suitable point, namely the roof apex, in combination with efficient lighting of the building without the introduction of wall windows or the ordinary form of roof skylight. Throughout the entire length of the building both sides of the ridge open upwards as shown in figure 40. This is accomplished by finishing the roof boarding and slating about 1 foot short of the ridge at each side of the roof and filling the opening with glazed sashes which, being hinged at the lower edge, open upwards as shown in the figure. This will give a ventilating opening 1 ft. 8 ins. wide with a roof built to a pitch of 30 degrees, and provided that the sides of any upper purlins and bridles are kept perpendicular. The sashes

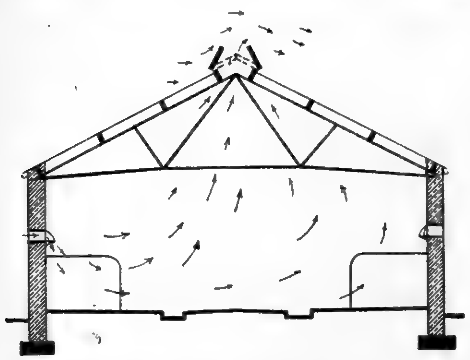


FIG. 40.—Findlay's method of ventilating a cow-shed. For details of construction see the text.

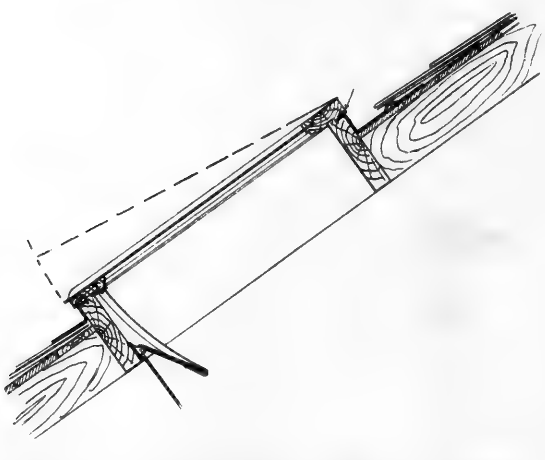


FIG. 41.—A Roof Skylight fitted with a quadrant.

are connected with a lever which by one movement can easily regulate the opening to the desired width. If so desired, the sashes can be divided into two or more sections and the two sides of the building be made to operate independently. To those who have not tried this system it might appear that down-draughts might take place, but it is found in practice that this does not happen. Objection

is sometimes raised to the method on account of the rain or snow that sometimes finds its way in, but in the case of a double byre or stable no harm can result as it would fall on the central passage, and in the case of single buildings a gutter is suspended under the ridge to catch and carry away any rain that may enter.

When both sides of the ridge are open, the wind striking on the weather side is directed upwards, passes across the opening and, by producing an aspirating effect, assists the heated and foul air to escape. The roof timbers that are exposed to the open are protected from the weather by covering them with zinc or bitumastic sheeting. The sashes may be of wood or metal.

The inlets for the fresh air are placed in the wall in front of the cows, and are so constructed that the air on entering is deflected in front of the animals.

This system is without question the ideal method of ventilating animal houses. It provides a perfectly free outlet for the foul air and gives sufficient lighting without wall windows.

Roof Lights or Skylights.—Another form of combined lighting and ventilating appliance is the roof light. It is most unsatis-

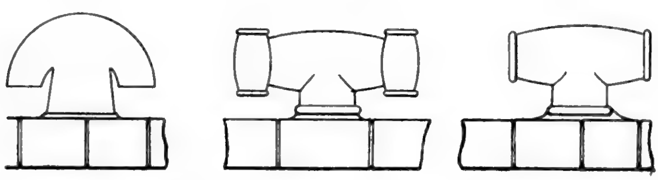


FIG. 42.—Three types of Fireclay Ridge Ventilators.

factory in every respect. When made to open, as shown in figure 41, the wind blows inwards and downwards causing cold air-drops. Skylights are usually situated about the middle of the roof slope, and cause a dead hot air pocket in the upper part of the roof. The hinges rust, quadrants or other opening appliances get out of order with the result that they are often permanently open, shut or half open.

Fireclay Ridge Outlets.—These are common on old-fashioned and on many new but badly designed byres and stables. They take a form similar to the ordinary fireclay T chimney can as shown in figure 42. They are almost useless and usually of such a poor outlet area as to be ineffective.

Outlet Shafts.—Outlet shafts and their uses have already been referred to on page 94. They are often employed in lofted buildings and may be circular or rectangular in section, the former being the better, and more effective and economical. The material

of construction may be zinc, galvanised or black iron. The combined sectional area of the shafts must be designed to accord with the required air changes previously indicated. The following points should be noted :—The greater the length of the shaft the greater is its extracting power. Bends in shafts retard the air current, but where they are unavoidable the diameter at the bend should be increased. Shafts should not be exposed to the open air more than is necessary, otherwise, in cold weather, the extracting power will be retarded.

Extraction Cowls or Ventilators.—A variety of extractors are made and sold as proprietary articles. The qualities claimed for them are that they prevent down-draught and accentuate the aspir-

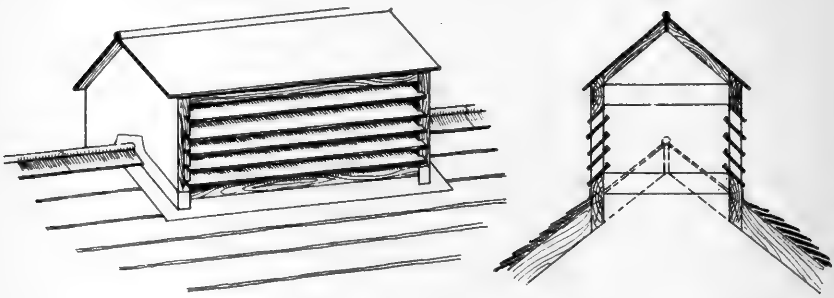


FIG. 43.—Illustration and section of a Louvre-Board Air Outlet Box fitted to the roof ridge.

ating action in the duct or shaft which they surmount. Many examples of these " extractors " may be seen in the *Architects' Compendium.*

Many exotic forms of terminal ventilators may be found on buildings, such as pivoted cowls, lobster backs, " old wives," revolving cowls and cowls fitted with gas jets or hot water pipes. Some are effective, but most are to be condemned in consequence of the amount of nursing they require to keep them in life.

Louvre-board Ventilators.—This type of air outlet terminal is very old but under many conditions, if properly constructed, is good and effective. Probably the neglect of this ventilator, combined with its improper position or design, is the cause of its frequent condemnation. It consists of any form of covered frame or box placed on the ridge of a roof, the sides of the box or framing being filled with a series of superimposed sloping boards or metal plates set at regular spaces in such manner as will permit of the escape of foul air and prevent the ingress of rain. The louvre-boards should be set at an angle of 50 or 60 degrees to the horizontal. By the relative proportion of the width of board and the spacing of

same, rain can be excluded under any but extraordinary conditions. It is advisable to have a weather fillet nailed to the upper edge of each louvre-board to form a water check. In the case of metal plates the upper edge may be turned up for this purpose. The boards or plates are let into grooves formed in the framing posts. This type of outlet should be kept clean and in good condition by regular painting. The perflating action of the wind passing through the louvred ventilator with its consequent aspirating effect is indicated in the figure. Down-draughts are frequently caused by the proximity of higher buildings or roofs. Adjustable or movable louvres are to be condemned as they are often neglected and readily get out of order.

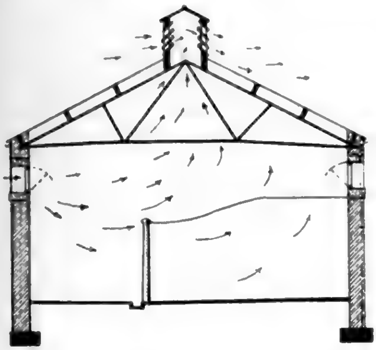


FIG. 44.—Showing the method of ventilating a stable with hopper inlet windows and a louvre-board outlet fitted on the roof ridge.

MECHANICAL VENTILATION.—Mechanical ventilation is adopted where for some reason a purely natural method is in itself either inefficient or impracticable. There are two methods:—(1) The *plenum* method whereby hot or cold air is forced into a building through ducts by means either of a propeller or cased fan driven by motive power; (2) the *vacuum* or *extraction* method whereby air is sucked out of a building by a fan. The extraction method has been found to be more efficient under varying conditions than has the plenum system.

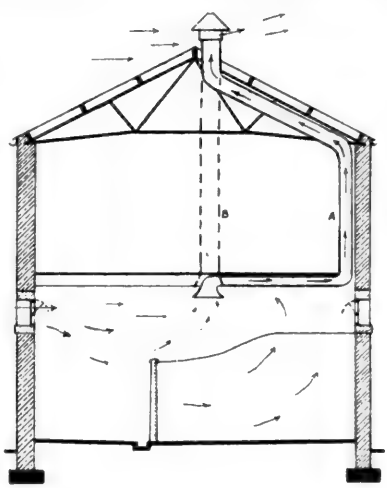


FIG. 45.—The ventilation of a double-story or lofted stable. The inlet of fresh air is provided for by hopper windows. The foul air escapes through flues either as shown by *A* to avoid breaking the loft or overhead stable space, or *B*, which is preferable by a direct flue carried straight up to the roof ridge. The flues are surmounted by suitable extraction cowls.

VENTILATION OF DOUBLE-STORIED STABLES.—It is not always possible to build stables with only one story, and in cities it is often necessary to stable horses in two or three flats one above the other. It is sometimes stated that it is not possible to pro-

perly ventilate any animal building in the absence of an open roof. Though it is true that open ridge ventilation is the ideal method, it is far from being the case that satisfactory ventilation is impossible by any other means.

The most suitable method of ventilating such stables is by the use of windows of the Sherringham type, one being placed at the head of each horse's stall; the windows on the weather side will act as inlets and those on the lee side solely as outlets, thus producing a cross-ventilation. Where there is no ridge outlet the size of the windows must be increased accordingly. The installation of extraction tubes or shafts as described on a former page should be effected where possible.

THE KING SYSTEM.—This method was evolved by F. H. King in 1889, and is used to a very considerable extent in America.* It consists of two sets of flues one of which provides the fresh air, while the other furnishes an escape for the vitiated air. The following instructions are taken from the official bulletin:—The inlet or fresh air flues should be placed in the exterior walls of the building and not more than 10 feet apart; the greater the number the more effective the ventilation, since they enable the fresh air to displace the foul air more rapidly. The outlet may include one or more flues, but should be so located as to provide the quickest means of removing the foul air. The outlet shaft is carried down to near the floor. The objects of placing the intake of the extraction shaft at such a low level are given as follows:—(1) To remove the carbon dioxide and the waste products of the lungs produced by breathing. This foul air settles near the floor and animals are compelled to breathe it with the impurities. (2) To dispose of the cold air in winter weather rather than the warm. The coldest air in a room is at the floor and the warmest at the ceiling. Fresh air is taken in through small flues placed at intervals along the side walls as shown in the figure. The outside opening is placed near the ground line, but may be higher in the wall if found necessary. It should not, however, be placed less than 3 feet below the ceiling to guard against the warm air flowing outward. The inner opening of the intake shaft is placed just under the ceiling and may be provided with a movable shutter to control the amount of air passing in. It is pointed out that for this system of ventilation to be successful the ceiling and walls must be practically air-tight. The object of having the air-inlet opening at such a high level is that the incoming air will mingle with the warm air found at the

* The King System of Ventilation, *Univ. Wiscon. Agric. Exp. Station, Bull.*, 164, 1908.

ceiling and become warmed before it settles to the floor. The construction of the foul air flues is of importance, as faulty construction has led to failure in the system. They should be as straight as possible, as every turn or bend greatly reduces the carrying capacity by increasing the friction of the moving air on the flue. A good ventilating flue should have the same qualities as a good

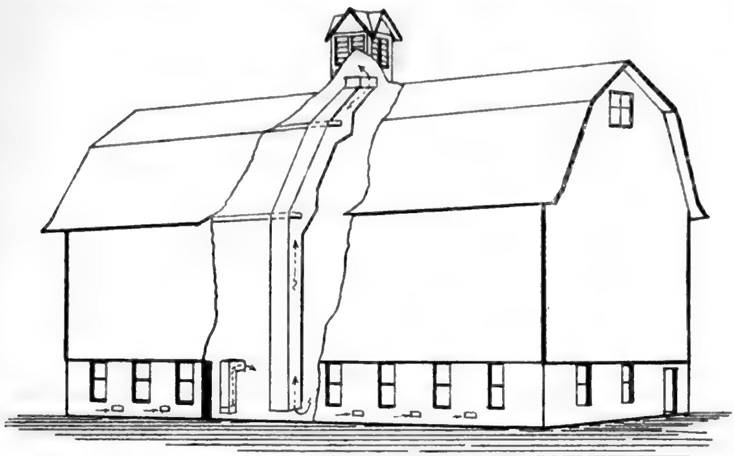


FIG. 46.—The King system of ventilating cow barns as adopted in America. (By permission from the Wisconsin Experiment Station Bulletin 164.)

chimney. It should rise above the highest part of the roof, so as to receive the full force of the wind. Where only one flue is used it should be placed as near the centre of the building as possible. Doors and windows must fit well. Foul air flues should be airtight and non-conductors of heat and cold. The lower opening should be about 1 foot above the floor level, and with as few bends as possible pass up to a height of at least 25 feet, and should always be 2 or 3 feet above the ridge of the roof or of any adjoining roof.

The King system of ventilation is unnecessary with the temperate climate of Great Britain.

TESTING THE EFFICIENCY OF THE VENTILATION.—A veterinary inspector may be called upon to give an opinion as to the efficiency of the ventilation of a cow-house, stable or other animal habitation. Local Authorities may require cow-keepers, under powers vested in them through the Dairies, Cow-sheds and Milk Shops Order, to make adequate provision for lighting and ventilation of cow byres.

No specific requirements are stated except that the total cubic air-space per cow may be defined, viz., not less than 800 cubic feet per head, but the ventilation and lighting must be to the satisfaction of the Local Authority.

It is difficult to set an arbitrary standard for ventilation, because what might be adequate in an exposed position would be notably deficient for some city byres that are closely surrounded by other buildings.

It is clear that the cubic air-space per animal must be sufficient to allow of satisfactory ventilation without the premises being too draughty. The cubic space must not be made up by giving an inordinate height to the building, that is to say the floor space must be sufficient. Local authorities are recommended by the Local Government Board that, in calculating air-space, no space shall be reckoned which is more than 16 feet above the floor; but if the roof or ceiling is inclined, then the mean height of the same above the floor may be taken as the height.

The question really depends upon the nature of the roof as has been already discussed, but a good working method is to construct the building so that the number of superficial feet in the floor is not less than one-fourteenth to one-fifteenth of the number of total cubic feet in the building. Thus in the byre dimensions suggested on page 172, the floor area is 65 square feet per animal, or one-fifteenth of the total number of cubic feet, and, in the case of the stable for heavy horses (page 148), the floor area is 136 square feet per head, or one-fourteenth of the total number of cubic feet. The net cubic space per animal must be calculated by making deductions for the space occupied by the animals, approximately 18 to 20 cubic feet per horse or cow, and by supporting pillars, if any, or other fittings that appreciably reduce the available air-space.

The position, nature, and capacity of all inlets and outlets must be noted, and it is important that all calculations be made for the total number of animals that the building is capable of holding, not for the number present at the time of the inspection. The position and proximity of other buildings must be carefully observed, as these may seriously reduce the ventilating capacity of both inlets and outlets.

If the inlets are placed too high in the walls they will not be so efficient as at a lower level, as air entering at a high level would tend to cause the hot and foul air to fall which is not desirable unless the King system of ventilation is in use.

A ventilating system should always be tested when the building has been in full occupation for some hours and, as far as possible, under average weather conditions. On first entering a building an ordinary observer, who does not spend the greater part of his working day in a badly ventilated animal building, will at once notice a difference in the smell and physical character of the air inside the

building from that of fresh outside air. The peculiar smell of animal-vitiated air was used by de Chaumont as a means of gauging the degree of atmospheric impurity, and he constructed the table which is here reproduced. While it is rather doubtful if the table is very trustworthy when used in connection with animal houses, it may be of some assistance.

	Percentage of CO_2 in the air due to respiratory impurity.
When the air smells practically as fresh as outside air . .	0.020
When the air smells rather close .	0.041
When it smells close . . .	0.067
When it smells very close . .	0.091

The percentage of CO_2 in the air can be approximately estimated by the *Angus Smith Method,* or more accurately by the *Lunge-Zeckendorff* or *Pettenkoffer* methods.

The Angus Smith Method.—If CO_2 is passed through lime water it combines with the CaO forming calcium carbonate which, becoming precipitated, gives a turbidity to the water; if the addition of CO_2 is continued beyond the point needed for the test, the turbidity vanishes owing to the formation of the bicarbonate of calcium as is shown in the following equations:—

$$Ca(OH)_2 + CO_2 = CaCO_3 + H_2O$$
$$CaCO_3 + H_2O + CO_2 = CaH_2(CO_3)_2$$

The amount of air required to be passed through a given quantity of lime water before cloudiness appears will indicate the proportion of CO_2 present. The method is as follows:—

Take a series of glass stoppered bottles, 20½, 10½, 8, 6½ and 4 ozs. in capacity, or in c.cs., 580, 300, 230, 185 and 125 c.c. capacity. Into the above series of bottles put ½ oz. of clear saturated *liquor calcis,* or baryta water, and wash the air contents of each by shaking, noting carefully which becomes turbid first, then interpret the result from the following table:—

Size of bottle in ounces.	If no precipitate, CO_2 per cent.
20½	0.03
10½	0.06
8	0.08
6½	0.10
4	0.15

The Lunge-Zeckendorff Method.—This is a more accurate method than the former, and requires more careful attention to details. As air containing an appreciable amount of CO_2 is acid to phenolphthalein, it follows that if it is passed through a slightly alkaline medium it will tend to neutralise the alkalinity, and if a standard alkaline solution be used and coloured by phenolphthalein and the amount of air passed through measured, it is possible to calculate the exact amount of carbonic acid gas in the air. The method is as follows:—The apparatus consists of a 70 c.c. flask fitted with a rubber stopper and two tubes as in a wash bottle, and an indiarubber valve pump of 70 c.c. capacity. Make a N/10 sodium carbonate solution, 5·3 grammes per litre, and colour with phenolphthalein; from this solution make the working solution by taking 2 c.c. of the above and making up to 100 c.c. with distilled water, boil, cool and make up to the 100 c.c. mark with distilled water. This solution will not keep, and must be freshly made on the day it has to be used. For each estimation take 10 c.c. of the working solution, place it in a flask, and at the place where you wish to examine the air slowly compress the rubber ball between the palms of the hands and force the air through the solution. Shake the bottle well and allow the pump to re-fill with air. Repeat this operation until the phenolphthalein is decolourised. The Na_2CO_3 is converted into the bi-carbonate by the CO_2 of the air thus:—

$$Na_2CO_3 + H_2O + CO_2 = 2NaHCO_3$$

Immediately there is excess of CO_2 the colour of the phenolphthalein is discharged. The number of times the ball has to be squeezed gives the amount of CO_2 as shown hereunder:—

2.	0.3 per 100.	11.	0.087 per 100.	20.	0.062 per 100.
3.	0.25 ,,	12.	0.083 ,,	22.	0.058 ,,
4.	0.21 ,,	13.	0.080 ,,	24.	0.054 ,,
5.	0.18 ,,	14.	0.077 ,,	26.	0.051 ,,
6.	0.155 ,,	15.	0.074 ,,	28.	0.049 ,,
7.	0.135 ,,	16.	0.071 ,,	30.	0.048 ,,
8.	0.115 ,,	17.	0.069 ,,	35.	0.042 ,,
9.	0.100 ,,	18.	0.066 ,,	40.	0.038 ,,
10.	0.090 ,,	19.	0.064 ,,	48.	0.030 ,,

With Pettenkoffer's method the reduction in the alkalinity of a fluid caused by passing through it air containing CO_2 is measured by the use of a standard solution of oxalic acid.

Examination of the Air for Particulate Bodies.—This may be done by exposing a series of slides, moistened with glycerine, in different parts of the building; the glycerine should cover a definite area of the slide, say 1 square inch, and the time of exposure should

range from one up to twenty-four hours; at the stated intervals the slides are subjected to microscopical examination.

A second method is by the use of a Pouchet Aeroscope. This is a funnel-shaped tube or flask the tube of which, drawn to a fine point, ends over a slide moistened with glycerine. The apparatus is enclosed in an air-tight box, and by means of a water aspirator air is sucked through the funnel and deposits its particulate matter on the slide, which can then be examined. Since it is possible to measure the volume of air passing through the funnel, the particulate matter for any given volume can be estimated.

Bacterial content of the air can be ascertained by exposing suitable nutrient media on plates and thereafter cultivating by incubation. The quantity of micro-organisms for a given volume of air can be determined by using Hesse's apparatus, whereby a known quantity of air is drawn by aspiration through a cylinder to impinge on nutrient gelatine, which may then be cultivated and the colonies counted.

The physical state of the atmosphere in a building may be judged by noting if it is moist and oppressive or relatively dry and pleasant. Evidence of excessive humidity is to be noticed on the windows or on any metal work, behind the doors and in corners of the building. Evidence of much moisture in the air of buildings is not in itself a reliable indication of the efficiency of the ventilation when the outside atmosphere is also heavily charged with moisture, that is when its relative humidity is high. If, however, the atmosphere inside a building is very moist on a cool, dry day, then the ventilation is not efficient. The temperature both inside and outside the building should be noted, as the degree of difference between them affords a very fair indication of the extent to which the place has been ventilated, provided that artificial heating is not employed. The thermometer, of which there should be at least one in each animal house, must be hung clear of the animals' exhalations and not directly in the path of incoming air. The thermometer should be of the wet and dry bulb combination so that the difference between the two readings may be observed. For more accurate work the readings should be noted twice daily, together with similar readings outside the house, and the relative humidity of each position calculated by means of Glaisher's tables (see page 40).

SECTION V.

BUILDING CONSTRUCTION.

This book is written for veterinary students and those whose calling will involve the inspection of and reporting upon animal habitations. Work of this nature demands a general knowledge of building materials and their uses, the construction of dairy farms and agricultural buildings, and the ability to interpret the plans and other drawings of existing or proposed buildings; therefore the information given in this section will help the reader to acquire the knowledge necessary to make such reports, prepare or criticise plans, and supervise the construction of buildings.

DRAUGHTSMANSHIP.

THE following hints should enable one to prepare drawings with that crispness and neatness which carries a feeling of conviction and accuracy with them.

The first essential is a proper drawing-desk of the correct height, higher at the back than at the front, with plenty of space on which to lay plans, books, instruments, colours, inks, &c. The drawing-desk may be made of whitewood with dressed frame and legs, and a sloping top made of grooved and tongued flooring or thick lining. It should be fitted with two drawers, one for drawings and another for drawing materials. The size of the office available and the requirements of the user will decide the size of the desk, but one about 8 feet long, 3 feet 3 inches wide on top, and 3 feet 3 inches high at the front is a most convenient and useful size. A desk of the foregoing width should be 3 feet 8 inches high at the back. The user must face the light, a good position for his desk being across a window.

A good yellow pine drawing-board is necessary, and much preferable to the ordinary thin, cheap type of butternut board, which invariably twists and warps. The finest drawing-board is that with a grooved back and heavy back bars fixed with screws in

brass slots and having a hardwood slip on the working edge, upon which the stock of the tee-square slides.

The tee-square may be of pearwood, but must be strong. The best type of tee-square is that with a thin mahogany blade, ebony drawing edge, and rebated ebony edge on stock.

A 60° and 45° set-square are necessary. They may be of mahogany, pearwood or celluloid. An extremely useful instrument, that should be on every drawing-board, is a celluloid protracting adjustable set-square, which facilitates the drawing of roofs and enables the draughtsman to set off or divide any angle with speed. Cheap drawing pins should be avoided.

Unless one is prepared to lay out a considerable sum of money on a case of first-class instruments, it is advisable to purchase only those likely to be of most use and of good quality. Cheap instruments are invariably of little use, and will only result in bad and inaccurate work. The following instruments may be purchased :—

(1) A pair of 6-inch compasses, with pen and pencil points.

(2) A pair of dividers.

(3) Spring bows for pencil and ink, for the purpose of drawing small circles.

(4) A good drawing pen for inking-in the completed work if desirable.

(5) A 12-inch scale (boxwood), divided into twelfths, and containing the following scales :—On one side $\frac{1}{8}$ inch to the foot, $\frac{1}{4}$ inch to the foot, $\frac{1}{2}$ inch to the foot, and 1 inch to the foot. And on the other side $\frac{3}{8}$ inch to the foot, $\frac{3}{4}$ inch to the foot, $1\frac{1}{2}$ inches to the foot and 3 inches to the foot.

(6) Good lead pencils graded H and HB are probably all that will be found necessary, but the taste of the user settles this matter, as well as the kind of work being done and whether paper is rough or smooth.

Good cartridge paper is usually employed for ordinary work, although hand-made paper is desirable for plans which must stand considerable wear or be kept for reference for some time.

For working plans clear tracing linen is indispensable, although for small works tracing paper may fulfil all the requirements, if taken care of.

In ordinary architectural practice it is found that a great many of the drawings are only in use for a very short period, during the execution of the work, and do not warrant the use of an even moderately expensive paper. For those who have such work to do, rolls of thin, tough, vegetable paper, sometimes called "bank-

note" or "detail" paper, is recommended. This is very suitable for working up sketch plans, plans of alterations, and even working drawings for works of minor importance. This paper, of which there is a variety of classes, usually takes colour and ink well, and is much more durable than the more expensive, although more transparent, tracing papers, which contain oil and turpentine, and, getting brittle, tear easily.

The draughtsman will also require a few bottles of drawing-ink —black, blue and crimson, and a few cakes of water colour. The following is a list of the colours required for ordinary use, with the materials which they usually represent:—

MATERIAL.	COLOUR.
Steel (in elevation) .	Light Prussian blue.
Steel (in section) . .	Strong Prussian blue.
Lead	Indigo or neutral tint.
Stone (in elevation) .	Light burnt umber.
Stone (in section) . .	Strong burnt umber, with a little crimson lake added.
Brickwork (in elevation)	Crimson lake, with a little burnt umber added.
Brickwork (in section) .	Vermillion or strong crimson lake, with a little burnt umber added.
Concrete (in elevation) .	Light indigo, with a very little crimson lake added.
Concrete (in section) .	Stronger indigo, with a very little crimson lake added.
Undressed timber (in elevation) . .	Raw sienna or gamboge, with a little yellow ochre added.
Undressed timber (in section) . . .	Burnt sienna.
Glass	A light wash of ultramarine.
Plaster	A light wash of Payne's grey.
Slates	Indigo or sea-green wash.
Tiles	A light wash of Indian red.
Finished woodwork .	A light wash of bright green.

Practice.—When starting a drawing, decide the scale to which the work is to be carried out, the number of plans, sections and elevations likely to be required on each sheet, and calculate the size of paper most suitable. A quarter of a double elephant sheet is a very suitable size for ordinary small work. Several small drawings are handier than one large sheet of drawings.

Always draw on the finished side of the paper, particularly if it is cartridge paper or hand-made paper. Pin the sheet to the board with the left hand edge about 2 inches from the edge of the drawing-board. Square the top or bottom of the sheet with the tee-square, after having pinned the top left-hand corner, holding the sheet by the right-hand lower corner to square it. Afterwards pin down the remaining corners without twisting the sheet. Use the tee-square with the left hand, keeping the stock close to the edge of the drawing-board.

The plans and elevations should be equally and neatly distributed over the sheet. Always start by drawing the scale a few inches from the bottom edge of the sheet, as a drawing is useless without its scale. Assuming that the plan to be made is that of an existing building which has been surveyed, start by laying down the ground floor plan, setting off the lengths of each line by means of the scale and dividers.

Drawings of old or new work should never be "inked-in" till they are found to be correct, nor till a definite decision has been come to as to the work which is to be done at the building.

Unless plans are for contract purposes or to be kept for record, it is not necessary to have them "inked-in."

Sketch plans of alterations should not be drawn directly upon the paper survey plan, but worked up on cheap, thin tracing paper or bank-note paper already referred to. This paper should be pinned over the survey plan, and alterations drawn on the tracing paper, along with the walls and partitions which are not to be altered. By this method alternative plans of alteration can be roughly shown, and when the selected method of alteration has been decided upon, the actual work can then be shown upon the paper plans.

In preparing plans for alterations it is a good practice to "ink-in" with light vermillion or crimson ink all the existing work, but in any case the walls and partitions at and surrounding the part to be altered. After the alterations are drawn, they should be tinted with colours to represent the various materials to be used, the red lines remaining and indicating the parts to be removed. The old walls and partitions which are to remain should thereafter be inked in or pencilled over with black, and filled in with grey colour. Old floors should not be tinted, but the new floors or repairs to flooring should receive a light wash of raw sienna. Beams should be drawn neatly with Prussian blue ink, and other new work tinted as indicated in the foregoing list.

Another method of showing alterations is to draw the new work on a separate sheet of paper, afterwards cutting it out neatly

and gumming one edge over the part of the original plan where the alterations occur. This is known as a " rider," and is sometimes used as a method of indicating alternative schemes on plans and elevations of new work.

Plans of completed work should never be kept in rolls in an office, but invariably preserved in a flat condition. Probably the best method is to store them in a portfolio or " folder " made from a large sheet of manilla paper folded across the centre, the name of the work being marked on the outside. Plans of small works can be kept in a " miscellaneous " portfolio, with a typewritten list of the contents, but larger works which involve a number of drawings should have separate portfolios.

Full size and scale detail drawings may be drawn on cartridge paper or " bank-note " paper. In any case the working copies are probably best executed on " bank-note " paper, drawn with pencil and coloured either by means of water colours or coloured crayon pencils.

No matter how accurately a drawing may be prepared, it should be figured as fully as possible to give the dimensions of the structure, openings, breaks in walls, floor heights, ceiling heights, &c.

Care should be taken that the added dimensions agree with corresponding overall dimensions. It is advisable that all dimensions given on plans and sections should be the bare structural sizes without any allowance for finishings such as strapping, lathing, plaster, &c.

SURVEYING EXISTING BUILDINGS FOR THE PREPARATION OF PLANS.

The instruments and appliances necessary to make a survey of existing buildings are as follows :—A 50 feet or 66 feet tape line; a surveyor's 6 feet rod; a 3 feet rule; a plumb line; a survey-book consisting either of ruled or plain paper, and a pencil. An intelligent and energetic assistant is indispensable.

Before starting to take measurements, the surveyor should walk through and examine generally the arrangement of the buildings to be measured, and their principal details of construction. If a group of buildings is to be surveyed, a start should be made with the largest and most regular of the structures, having a long, straight wall such, for instance, as the main cow-shed. This will form a base from which diagonals and tie measurements may be taken to fix the relative position of the various buildings on paper. Care should be taken, in sketching out the plan of the building to be

measured, that sufficient room is left on the page of the survey-book to take in all the connections or out-lying features. Details such as doors, windows, fittings, &c., should not be sketched in before the whole of the outer walls of the building are shown on plan.

Squared paper is used by some surveyors for sketch surveys.

It is only necessary to see that the proportion of the building is fairly accurately represented in the sketch. System must be observed in taking the measurements, if errors, and consequently additional visits to the building, are to be avoided. The outside dimensions of the buildings should be taken on all frontages, starting at a corner and reading off running measurements to the full extent of the tape line if necessary. That is to say, the assistant holds the ring of the tape on a corner, whilst the surveyor measures the daylight distances of each window and door opening, and enters them in his book upon the sketch plan, using arrow-heads to denote the direction and point of measurement.

The inside dimensions of each apartment should be taken, measuring along each wall and taking the diagonal measurements from corner to corner. All doorways, windows, chases, breaks, stalls, gutters, roof principals, roof lights, hatches, ridges, &c., should be measured from definitely fixed points by running measurements, and marked carefully upon the plan, keeping in view that these measurements are to be transferred to a plan drawn to scale by the surveyor or his draughtsman.

Each flat should be measured in a similar manner, and the direction of the floor joists shown clearly in every case.

Sketches should be made of each elevation of the building, and the heights of all openings and details of the doors and windows, pipes, roofs, &c., measured and shown upon the plan and elevations. A cross-section, no matter how rough, should also be sketched and all the principal heights measured and shown.

In measuring elevations, the wallhead gutter can be used as a datum line from which ground levels and the position of sills and lintels can be measured. The thickness of all walls and partitions, and the materials of which they are composed, should be noted, and the description and condition of floors, roofs, walls and fittings should be jotted on the side of the drawings, with arrow-headed lines indicating the parts to which each note applies.

If a drain plan of the existing premises is not available, all the drains should be carefully surveyed, the depths and position of manholes noted, and the direction of flow marked upon the survey plan.

After the survey has been completed, the surveyor should enter

in a note-book, systematically and under proper headings, the condition of all parts of the building, noting particularly those parts which require repair, and the details of construction in building which are to be altered. A carefully-made survey is always worth the time spent upon it.

See figure 47, which is a reproduction of a simple survey embodying all the points referred to.

CHOICE OF SITES.

Farm Building Sites.—In the selection of a site for a new farm steading, the following considerations must be kept in view :—

(1) The avoidance of clay topsoil. The best type of soil is that composed of gravel, sand or chalk.
(2) The proximity of good roads is essential.
(3) A plentiful and clean water supply is indispensable.
(4) Facilities for easy and economical drainage.
(5) Shelter from prevailing winds, particularly northerly and easterly (cold) winds.

Any difficulty experienced in selecting a sheltered site is sometimes to be overcome by erecting barns, granaries and such-like buildings to the windward side, but not contiguous with the animal houses.

Sites for Town Buildings.—In cities the choice of site is usually very limited, but the greatest care should be taken in the selection of a suitable site for cow byres or stables.

The following conditions should be avoided :—

(1) Low-lying and damp land, such as riverside, reclaimed, or made-up ground.
(2) Sites adjoining canals.
(3) Congested sites or those surrounded by highly-built areas.
(4) Sites in districts containing objectionable industries such as chemical works, tallow and manure factories and gasworks.

ARRANGEMENT OF FARM BUILDINGS ON THE SITE.

In nearly all cases the arrangement of the various buildings which comprise a farm steading will in the first instances be ruled by (*a*) the proximity of roads; and (*b*) the configuration of the ground.

The rules for planning may be briefly stated as follows :—

(1) The farm buildings should be kept well away from the farmhouse and workers' cottages, but consideration

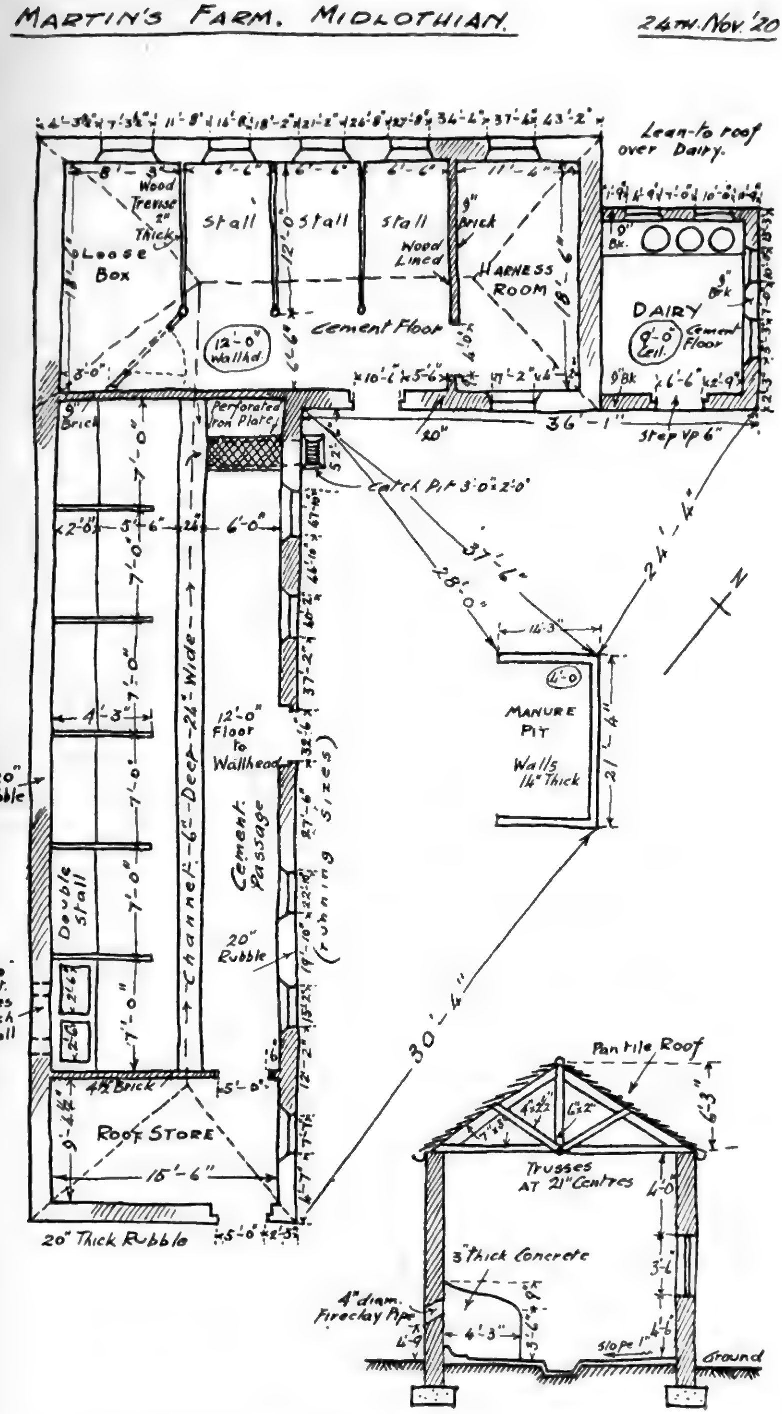


FIG. 47.—Reproduction of a survey sketch showing the method of taking measurements, &c.

must be given to the distances not being *too* great, otherwise the workers might be reluctant to turn out at night or in bad weather to give the animals the required attention.

The farmhouse should in no case be placed to the leeward side of the steading or farm buildings, in relation to the prevailing winds. Attention to this point tends to prevent flies and smells from the manure heap being blown towards the dwelling-house.

(2) The arrangement of a group of buildings should be such as will admit of the free passage of sunlight and air, and ensure economy of labour in the tending and feeding of the animals. The outstanding bad feature of most farms is that the buildings have been added to from time to time on no definite plan, as occasion seemed to demand, resulting in many cases in a hopeless muddle which involves labour and running about out of all proportion to the capacity of the farm.

(3) The court formed by a group of farm buildings, in any of which buildings animals are housed, should be so proportioned that the least dimension of the court's surface shall not be less than twice the height above the ground of the ridge of the highest building forming the group. From this it should not be assumed that all farm buildings ought to be grouped to form a courtyard, but there is no objection to a quadrangle if the area is great enough to give plenty of ventilation. The rule given above would work out at a quadrangle measuring 36 feet in its least dimension if the highest building measures 18 feet from the ground to the ridge.

An example of a new farm steading embodying desirable conditions is shown on the plan in figure 48. This plan should be carefully studied, as it incorporates nearly all the points considered desirable for a farm in northerly latitudes.

It will be seen that the main buildings are arranged to form three sides of an open court, facing approximately south-west. By this arrangement the front of all the buildings receive any sunshine for part or whole of the day, whilst the animal buildings are protected from the cold and damp east winds which would be prevalent on east coast holdings.

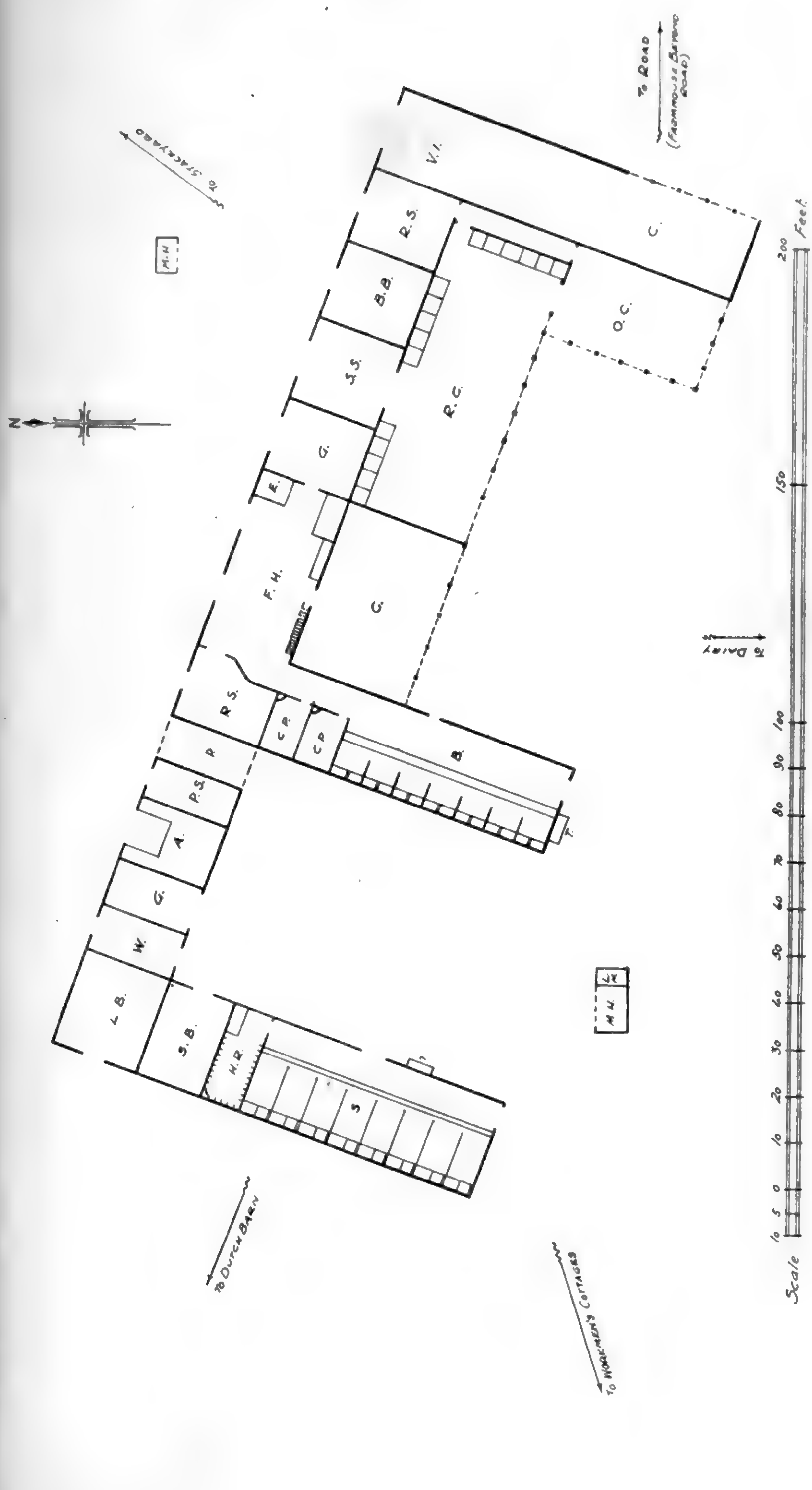


FIG. 48.—Plan of a Farm Steading.

S. Stable for horses. **H.R.** Harness room. **S.B.** Sick box. **L.B.** Loose box, for foaling, &c. **W.** Workshop. **G.** Garage or gig house. **A.** Artificial fertilisers (raised floor with recess for carts at ground level). **P.S.** Potato store. **P.** Pend. **R.S.** Root store. **F.H.** Food house. **E.** Engine room. **G.** Granary. **S.S.** Straw shed. **B.B.** Bull box. **V.I.** Valuable implements. **C.** Carts, waggons, &c. **R.C.** Roofed-in cattle court. **O.C.** Open cattle court. **C.P.** Calf pen. **B.** Byre for 14 cows. **T.** Drinking trough. **M.H.** Manure Heap. **L.M.** Liquid manure.

BUILDING MATERIALS.

The following notes on building materials are confined to those in general use for ordinary farm buildings. There is a great variety of proprietary articles made, many of which are good and useful, but these, owing to their cost, are out of the question in most agricultural buildings.

Bricks.—Bricks are probably the oldest form of standardised building material. Modern bricks are made either of a natural clay or a suitable brick earth. To the former must be added any of the necessary ingredients in which it is deficient. All clays and brick earths vary in character. *Natural plastic clays* are composed of silica and alumina, and contain a very small proportion of lime, magnesia, sodium and other salts. They are inclined to shrink if used alone, and attain great hardness when burned.

Brick Earth or loam consists of clay (*i.e.,* silicate of alumina) and sand. The latter prevents shrinkage and cracking, but reduces the hardness of the resultant brick. Most loams require the addition of lime as a flux, in order that the materials may be bound together. Marls or calcareous clays contain a large proportion of chalk. Suitable brick earths, whether natural or artificial, should contain such proportions of carbonate of lime and oxide of iron, &c., as will form a sufficient flux to fuse the constituents when in the furnace, but an excessive quantity will cause them to run together, and result in an over-burned and badly-shaped brick. The oxide of iron in a brick helps to bind the brick, and gives it its colour, whilst the carbonate of lime is purely a binding material.

Bricks should be of regular and uniform size, shape, texture and colour, quickly and thoroughly burned right through. They should be free from cracks and flaws, sharp on the arrises, and give out a clear ringing sound when struck with a hard material. It being impossible to receive delivery of all bricks in this perfect condition, those slightly damaged are quite good for building in concealed positions, provided that the brick is hard and well-burned. Moderately rough, irregular and chipped bricks need not be objected to for partitions or walls which have subsequently to be plastered or covered in any way. Porous bricks should never be used in foundations nor in external walls. They are sure to absorb water, and likely to weather badly. It is economical to build the brickwork of agricultural buildings in cement mortar, as it results in much more durable and water-resisting work, reducing depreciation and giving a stronger result than the use of lime mortar.

Ordinary building bricks of the best quality should be selected

for all good work. They should be dipped in water before being built, in order to remove dust and prevent the brick from immediately absorbing the water from the mortar. In building brickwork, place the most thoroughly burned bricks to the exposed surfaces. Dry bricks when soaked in water should not absorb more than one-sixth to one-eighth of their weight. This is a fair test for bricks which are to be built in positions exposed to the weather. The weight of a brick varies from 5 to 7 lbs., according to its density. The average weight of a cubic foot of brickwork is one hundredweight.

Ordinary Building Bricks. — Ordinary building bricks vary slightly in size according to the brickwork or district in which they are made, but the Royal Institute of British Architects has agreed upon a standard size for bricks with the Brickmakers' Association. Without going into the details of the specification, it will be sufficient to state that the maximum size of a brick should be 9 inches by $4\frac{3}{8}$ inches by $2^{11}/_{16}$ inches thick, and the minimum size $8\frac{3}{4}$ inches by $4^{5}/_{16}$ inches by $2\frac{5}{8}$ inches thick. Such bricks, when built with $^{5}/_{16}$-inch beds and $\frac{1}{4}$-inch joints, will measure 1 foot in height over four courses and four beds, and will ensure correct bonding in all thicknesses of walling.

Bricks are hand-made or machine-made, but in any case are moulded. Hand-made bricks are usually wire-cut, and have no frog or depression, which results in a heavier brick and does not bond so well owing to the absence of the frog. Machine-moulded bricks are usually more regular, have a frog on one or both beds, and usually bear the name of the brickwork at which they are made. There is such a variety of ordinary or common bricks that it is impossible to give a list of them. The reader should obtain samples of those procurable in his own district. The ordinary building bricks known as "composition" bricks are not made from a natural brick-making clay, but have the necessary ingredients brought together from various sources.

Ordinary clay and composition bricks are obtainable in various shapes for special purposes. *Bullnose bricks* are used for forming rounded corners at doors, windows, piers, corbels, window sills and other projecting parts which, if built with a sharp arris, might injure animals. *Splayed bricks* are used for intakes, sills, window openings and corbelling. Ordinary bricks, cut to a suitable size and used as closers for scuntions, are known as *bats*.

Facing bricks are special bricks made in a variety of kinds for building with ordinary brickwork to give to walls a finish, durable, sanitary or decorative as the case may be. The cheapest and best

form of facing brick is a *machine-pressed clay brick* made from carefully prepared pug. These bricks present a more impervious skin to the weather, and are usually of a pleasing and uniform colour.

Terra-Cotta Bricks. — Terra-cotta bricks are made from any good clay or mixture of clays which will vitrify at a moderate temperature. They may be obtained in all tints, varying from a buff to a deep red. The colour of terra-cotta work depends upon the proportion of oxide of iron which it contains, the deeper reds resulting from as much as 10 per cent. of oxide of iron. These bricks are rather expensive, but result in a most durable and weather-resisting surface, have fine arrises, and can be built with close joints. They are used for facing domestic and commercial buildings, and form a good sanitary dado for walls in byres, stables, stable-yards and washing-courts. Terra-cotta work lends itself well to moulding into any shape or decorative form.

Enamelled Bricks.—Enamelled bricks refer strictly to those finished on one or more surfaces with coloured or white enamel, but the term is often loosely applied to cover enamelled, glazed and salt-glazed bricks, which are three totally different products.

Enamelled fireclay goods of any description, whether bricks, tiles or sanitary fittings, are easily distinguished by reason of their opaque enamel, which does not depend in any way upon the body of the brick for its colour. Before firing, the surfaces to be treated are dipped in the enamel solution, passed into the kiln, and fired.

Glazed Bricks.—Glazed bricks are really glass faced, but they must have a face of china clay, as the glazing, being transparent, would show all the inequalities of an ordinary clay brick and present a rough surface. The china clay facing enables the brickmaker to start with a fine, smooth face. The glazing may be clear or coloured. Glazed bricks are easily damaged on the surface if struck with a sharp pointed instrument, and such fractures are liable to lead to an extension of the damage by crazing, cracking and the absorption of moisture and dirt.

Salt-Glazed. — Salt-glazed bricks are ordinary, good fireclay bricks which have common salt thrown upon the surface while in the kiln. This causes the brick face to flux, and results in a light or dark brown glaze. These bricks are the cheapest form of impervious facing brick, and should be used on the lower parts of the walls of all animal habitations. They present a sanitary surface which may be washed with ease.

Blue Bricks.—Most blue bricks are made in Staffordshire from clay which contains from 7 to 10 per cent. of oxide of iron, and are burned in the kiln at a high temperature. They are the hardest

and most durable of all bricks made, and are consequently used for engineering purposes such as the piers of railway bridges, the lining of railway tunnels, and other works which have to sustain heavy stresses.

They are sometimes designated as " Staffordshire Blue Metallic Bricks," and are recognisable by their deep blue-black colour and smooth metal-like face. They are useful for the jambs of gateways, stable doors, dadoes of courtyards and other situations likely to receive rough usage.

Staffordshire blue bricks specially made for paving stables are much in use. They are practically non-porous, extremely hard and very durable, but, unfortunately, they are slippery. To overcome that they are usually grooved in process of manufacture, although the grooving gives rise to another fault, viz., a lodgment for dirt and moisture. When these bricks are used the groove should be not less than $\frac{3}{4}$ inch wide, not more than $\frac{1}{4}$ inch deep, and should run with the long axis of the brick.

Dutch Clinkers.—Dutch clinkers are only used for paving. They are very hard, well-burned bricks, vitrified throughout, and occasionally warped in the kiln. Their size is about 6 inches by 3 inches by $1\frac{1}{2}$ inches thick, and the colour bright buff, although the addition of oxide of iron will yield a black paving brick. They are chamfered on the edges, thus forming a grooved floor to resist slipping (see section on Flooring).

Perforated Bricks.—Perforated bricks are ordinary building bricks made with a number of perforations running from bed to bed. They are frequently used in the south of England and London for lightening the work, but are rarely used in Scotland.

Hard pressed *ventilating bricks* or *air bricks* are sometimes used instead of gratings. They may be had in a great variety of patterns (see Ventilation).

Firebricks.—Firebricks are made to resist heat in furnaces without melting or spaling, therefore they do not contain iron and very little lime or salt, any of which would act as a flux under great heat. The best fireclay for firebricks contains about 97 per cent. of silica or free sand, to which 1 per cent. of lime is added to bind the material in moulding. Ordinary bricks contain about 50 per cent. of sand, the remaining components being alumina, lime and iron.

Figure 49 illustrates the various shapes in which bricks are obtainable.

TILES.—Ordinary roofing tiles, usually red in colour, are made from a good plastic clay. The flat plain tiles, much used in England

for all classes of work, are made in a great variety of qualities. Great progress has been made in the manufacture of these tiles, resulting in fine colours and textures for use in domestic work and reproductions of old roof coverings. The plain roofing tiles are made $10\frac{1}{2}$ inches by $6\frac{1}{2}$ inches, and have two nibs on the underside of head for hanging on to the tiling laths, or have two nail or

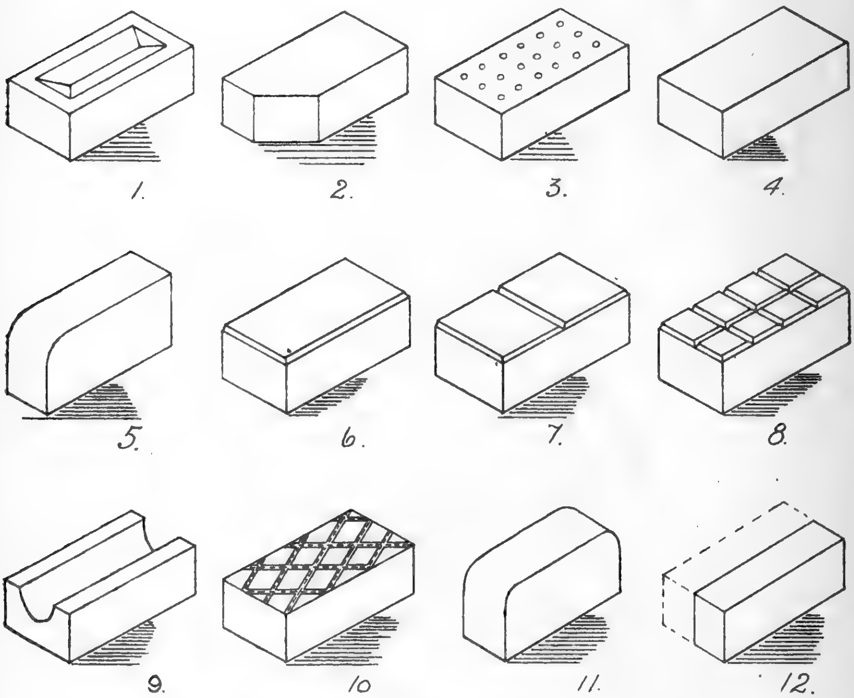


FIG. 49.—Various patterns of bricks.
1. Machine-pressed brick with a frog. 2. Chamfered brick. 3. Perforated brick. 4. Hand-made or wire-cut brick. 5. Bullnosed brick. 6. Chamfered clinker. 7. Two-panel paving brick. 8. Eight-panel paving brick. 9. Gutter brick. 10. Diamond paving brick. 11. Double bullnosed brick. 12. Queen closer.

peg holes. Some tiles are provided with both holes and nibs. All are slightly bent to ensure the tail lying close to the lower tile. Smaller tiles, 8 inches by $6\frac{1}{2}$ inches, are made for use at the eaves course. Tiles should not be laid at a flatter pitch than 45 degrees.

Pantiles, commonly used on sheds, byres and temporary buildings, are rough and heavy, and do not keep out the wind unless torched on the underside. They are popular in some districts, as they can be laid on roofs with a pitch as flat as 25 degrees, and in consequence of the ease of fixing and removing. Pantiles are roughly bent, and provided with nibs for hanging on tiling laths. Hips and valleys in pantiled roofs are finished with half-round

tiles. *Glass Pantiles* are obtainable for insertion in pantiled roofs. They can be inserted in an old pantile roof in a few minutes.

The weight of plain tiles and pantiles for roof covering, along with their bad weather-resisting qualities, has led to the introduction of a variety of patent tiles with special formations to resist wind and rain.

Ridges and *copes,* plain and ornamental, are obtainable in tile, fireclay or terra-cotta for roofs, walls, skews, &c.

Building Stones.—Stones used for building purposes may be divided geologically into two classes, viz., those derived from the igneous rocks and those from the sedimentary rocks. To the former class belong granite, whinstone, trap-stone, &c., and to the latter class sandstone and limestone.

Igneous Rocks.—*Granite* varies greatly in composition and colour. Durable granite consists chiefly of about 50 to 60 per cent. of quartz, 30 to 40 per cent. of felspar, and 10 per cent. mica. These proportions vary, but the details may be obtained from any good book on building stones. The colours vary from light to dark grey, light pink to dark red, and, in the case of some Norwegian granites, from light blue to dark green.

The best granites come from Aberdeenshire, Guernsey, Devon, Cornwall, Westmoreland, and Wicklow in Ireland. By reason of its great strength it is in demand for heavy engineering work, in the piers of viaducts, arches, sea-walls, &c. It is sometimes used for paving setts, but is apt to become slippery. For farm building purposes probably the only use to which granite can be put is that for paving stable-yards in the form of setts.

Whinstone is a close-grained dark blue or black stone with no definite bed or line of cleavage. It is used principally for road-metal, the aggregate of concrete floors, and for paving setts, being superior in many respects to granite for the latter purpose. In the whinstone districts it is used for building dry dykes, walls and the walls of buildings, but the building of whinstone in mortar is an art confined to the masons in the whinstone districts. It is not to be recommended for building, as it is inclined to draw damp and sweat on the surface.

Sedimentary Rocks.—Sandstone consists of quartz in the form of sand, held together by the carbonates of calcium and of magnesia, the oxide of iron and silica, &c. Sandstone is most in demand for rubble building and hewn work, owing to its regularity of texture and workability. The durability of the sandstone depends upon the power of the binding material, and its ability to resist weather. The sand or quartz is, of itself, indestructible.

The hardest varieties of sandstones are greatly in demand for paving, copes, steps, foundation-blocks, &c. Sandstones vary in colour, even in one quarry, the shade depending upon the amount and condition of the oxide of iron which it contains. Common colours of sandstone are white, grey, brown, yellow and red.

All sandstones should be built on their natural bed, that is to say, with their line of cleavage horizontal. Stones set on their edge weather very rapidly, particularly when the line of cleavage is parallel with the direction of the wall, stones being so placed, flaking off with each succeeding spell of rain and frost. Stones built in arches should be set on edge, with the plane of cleavage at right-angles to the face and soffit of the arch in order that the layers composing the stone may present their faces to the line of pressure. In selecting a sandstone, the reputation of which is unknown, it is a safe guide to look for bright, clean and sharp appearance in the texture when the stone is broken. A dull, earthy appearance in any stone indicates liability to decay.

Limestone is calcium carbonate in combination with iron, silicum, magnesium, &c. Well-known examples of limestones are (1) Portland Stone, obtained from the Upper Oolite series of sedimentary rocks in the island of Portland; and (2) Kentish Rag-stone. This latter is a compact limestone of a bluish tint, and is chiefly used for rubble building, paving setts, road-metal, &c. It is mixed with a soft calcareous sandstone, porous and perishable, which may be found adhering to it. It is very difficult to dress, and sometimes contains nodules of iron, which cause rust stains to show on the stone after exposure; (3) Bath-stone. This stone varies in colour from white to creamy-yellow. When first quarried it is soft and moist. It may be cut out by a saw, and is easily worked for fine carving. After exposure to the atmosphere it hardens, and is very durable.

Slates.—The chief varieties of slates obtainable are (1) Welsh slates, which have a good cleavage and may be split into very thin metal; and (2) Westmoreland slates, which are hard, tough and very durable, in a variety of colours presenting a very pleasing appearance.

Scottish slates from Ballachulish, Easdale, Aberfoyle, and a few other quarries are very durable, but are thick and heavy. The weathering properties of a slate depend upon its non-porosity and the absence of white iron pyrites. A good slate should give out a sharp ring when struck. It should stand trimming and holing without fracturing. Slates may be tested by weighing them before and after twenty-four hours' immersion in water. Any slate with

a large amount of absorption should be discarded. A slate, set on edge in water to half its height, should not absorb water in the upper and unsubmerged part. In a really good slate no sign of moisture will be seen above the water line.

The following are the usual sizes in which slates are supplied for ordinary building purposes :—

Doubles, 13 inches by 6 inches.
Ladies, 16 inches by 8 inches.
Countesses, 20 inches by 10 inches.
Duchesses, 23 inches by 12 inches.

Thick slabs of slate are sometimes used to form cisterns or other containers of water. Such cisterns are not to be recommended, as the liability of the joints to leak make them unhygienic and unreliable.

Limes, Mortars and Cements.—Lime for building purposes, such as making mortar and plaster, is obtained by heating limestone, limestone chalk, shells or any substance composed of calcium carbonate.

The limestone is burned in a kiln, along with fuel, in order that the carbonic acid gas and any moisture are driven off and escape into the open air.

Pure chalk lime is burned in " flare kilns." These kilns are arranged so that only the flame from the furnace comes into contact with the stone. The common, old-fashioned kiln for preparing ordinary lime " shells " is usually built on a hillside in proximity to the quarry. This arrangement enables it to be easily filled from the top, which is open and almost level with the high ground. The firing and emptying is done from the draw-hole at the low level. In these kilns the coal and limestone are piled up inside the stone-built kiln in alternate layers, and finished off at the top in the form of a cone. The firing of the kiln takes about a week, the time depending upon the size of the kiln. After the kiln is cooled the fire-bars at the bottom are removed, and the lime-shells or " quick-lime " fall out and are removed in carts. Lime-shells should be used as fresh as possible, as they deteriorate by exposure to the atmosphere, from which they absorb moisture.

For the preparation of ordinary building mortar without the use of a mortar mill, one part of lime shells is placed on the ground or on a cement floor and surrounded by about three parts sand, and the whole thoroughly wet. The quicklime immediately absorbs the moisture and begins to slake by effervescing violently, giving out heat and falling into a fine powder. By this process the caustic

properties of the quicklime have been lost, and the substance is converted into hydrate of lime.

By mixing the slaked lime with the sand, and adding a sufficient quantity of water, lime mortar for building purposes is produced. Pure slaked lime has little strength as a mortar without the addition of sand. The proportion of sand to lime, in preparing mortar, depends entirely upon the characteristics of the slaked lime and of the sand used. As pure slaked lime hardens on the surface by absorbing CO_2 from the air, the unexposed parts of the mortar will remain soft and unsuitable as a mortar. The addition of sand permits the entry of the air, and enables the mortar to set into the form of a cement with binding qualities.

In preparing lime for plasterwork, lime shells are slaked in an "ark," which is any form of enclosure or tank which will hold the quantity to be slaked. Sometimes an "ark" is formed in a plasterer's yard by enclosing a corner with sand, filling in the lime shells and applying water in sufficient quantity to reduce the shells to an inert and saturated condition to ensure thorough slaking and prevent blisters and "blows" in the finished plasterwork. After thoroughly cooled, the sand in required proportion is mixed with the lime, and the whole left for from 4 to 6 weeks to sour, or weather, before use. Ox or goat hair, or manilla fibre, in the proportion of one pound of hair to every two cubic feet of "coarse stuff," should be mixed with the plaster lime in order to bind the material into position in the building.

The plaster just described is used for the first and second coat of all ordinary three-coat work. The third and finishing coat is executed with lime-putty or "fine stuff." This is the resultant of slaking the pure quicklime as described, but without the addition of sand, the water being allowed to evaporate, leaving a white, putty-like mass which forms the finishing coat in plasterwork. For very fine work the fine stuff just described must be carefully run through a sieve and protected from dirt.

For executing urgent work or repairs it is often necessary to use gauged plaster, which sets more rapidly than ordinary three-coat work. Gauged plaster is executed with the addition of one-fifth of plaster of Paris to the plaster-lime or mortar. This work can be executed in two or three coats, due to the quicker setting, but for good class work slow-setting, thoroughly-worked ordinary three-coat plaster cannot be excelled.

Cornices are usually run with plaster lime to which from 30 to 50 per cent. is plaster of Paris, which causes rapid setting and enables mouldings to be run sharply and accurately. In the use of highly

gauged stuff only small quantities may be mixed at a time, that is, just as much as the workman can use before setting takes place.

Plaster of Paris is obtained by the partial calcination of gypsum (hydro-sulphate of lime), so that it parts with its moisture. It is used for gauging plaster, running mouldings, and for forming castings or enrichments to be applied to cornices, ceilings and other plastered surfaces. It is invaluable for running arrises or rounded corners.

There are a number of prepared plasters on the market, which are usually sold in sacks or barrels ready for use. There is a similarity in the composition of most. These prepared plasters must be kept perfectly dry before use, otherwise they will be useless.

Keene's Cement is a hardened form of plaster of Paris, which sets rapidly and can be made to take a surface almost like china. It is invaluable for forming angles, skirtings, and other ornamental parts in exposed positions where strength is required.

Portland Cement.—Portland cement has become probably the most important of building materials, being used for foundations, floors, paving, building purposes and an endless variety of structural and engineering works. It derives its name from a supposed similarity in appearance to Portland stone. Chalk and clay are the components of Portland cement. They are mixed together by the "wet" process. The proportions of chalk and clay used depend entirely upon the composition of the chalk before it is burned. It is necessary to obtain a mixture containing from 25 to 30 per cent. of clay. If pure white chalk containing no clay is used, three parts of chalk are mixed with one part of alluvial clay or mud, the measurements being by bulk. If the chalk itself contains a proportion of clay, the proportion of clay added will be relatively modified. The method followed is to mix the chalk and clay in water till it attains the consistency of a creamy liquid known as "slurry." This is allowed to settle in large tanks or reservoirs for several weeks. When the deposit becomes nearly solid, the liquid is run off and the solid dug out, dried over coking ovens, burned in kilns at a high temperature, and afterwards ground to a fine powder. London Portland cement, which is in world-wide demand, is made principally on the Thames and Medway. The colour varies from a bluish-grey to a light brown. It weighs from 110 lbs. to 120 lbs. per Imperial striked bushel. An average weight for general use may be taken as 112 lbs. per Imperial striked bushel. The variation in weight depends upon the degree of temperature and the duration of burning, as well as upon the fineness of the grinding.

The strength of the cement depends largely upon the fineness of the grinding. The standard specification for Portland cement

demands that, when sifted through a standard sieve having 2500 holes to the square inch, there shall not be more than one-half per cent. by weight of residue; when sifted through a sieve having 5776 holes to the square inch there shall not be more than 5 per cent. residue; and when sifted through a sieve having 10,000 holes to the square inch there shall not be more than 12 per cent. of residue.

The following are the principal tests for Portland cement:—
The Time Test, which is carried out by making a pat of neat cement gauged with the minimum of water at 60° Fahr., and placing on a glass slab. The pat of cement should not commence to set in less than eight minutes, nor take longer than 5 hours to set.

The Expansion and Contraction Test, which is carried out in a Faija apparatus, in which a pat of cement is submitted to moist heat and warm water at temperatures of 110° and 120° Fahr. respectively, when it should show no signs of cracking nor of expansion after 24 hours.

The Test for Tensile Strength, which is the most important, is carried out by forming briquettes of neat cement in a metal mould to form a double dove-tailed block which will fit into the jaws of the testing machine. The block should be gauged with the minimum of water on a sheet of glass or other non-porous substance, placed in water for 24 hours after gauging, and on being tested with the machine should have an *average* tensile strength of not less than 350 lbs. per square inch after 3 days, 450 lbs. after 7 days, and 550 lbs. after 28 days from the time of making the briquette.

Portland cement should be kept in a dry store. It should not be purchased in large quantities, which would involve its being stored for more than about 8 weeks, as it will draw damp and set in the sacks.

Cement Mortar.—Cement mortar for building purposes is composed of about three parts clean sharp pit sand, or river sand, and one part Portland cement, mixed with clean water free from organic matter or other impurities. It must be used fresh as it sets rapidly. Mortar left over at the end of a day must not be mixed with fresh material.

Cement Concrete for the foundations of walls, retaining walls, &c., is composed of an "aggregate" consisting of clean broken stones, bricks or large gravel, clean sharp sand and Portland cement mixed with clean water. The proportions of foregoing vary with the nature of the work and the class of aggregate and quality of cement used. For ordinary foundations the following is recommended:—

Stones or bricks broken to pass a 3-inch ring	.	4 parts.
Clean sharp sand	.	2 parts.
London Portland cement	.	1 part.

Water in sufficient quantity.

The material should be mixed on a close board, or stone or cement pavement (not on soil), turned over twice dry and once after being wet, immediately thereafter being turned into the foundation tracks.

Cement Plaster, consisting of clean, sharp sand and Portland cement mixed in three or four to one proportions, is used for rendering or plastering the inner or outer surfaces of walls, partitions, cow byres, divisions, piggery partitions, &c. Care should be taken to avoid using a plaster too rich in cement, otherwise hair-cracks or crazes will develop. A sand-faced finish is preferable to a polished one in this respect, but it is nevertheless more difficult to clean, as in the case of a sick loose-box. Cement plaster lends itself to the introduction of rounded corners and angles, and to a hygienic finish adjoining metal fittings in stables.

Harling or Rough-Casting for the outer face of walls consists of cement plaster finished on the surface with pebble or crushed granite dashing.

Reinforced Concrete consists of fine concrete strengthened with iron or steel rods or expanded steel, so placed that the reinforcement will take up the tensile strains set up in the concrete. It is now extensively used for the formation of stanchions, beams, partitions, retaining walls, tanks, stall divisions, upper floors, &c.

Asphalts. — True mineral rock asphalt is used in different forms for paving roadways, covering platform roofs, and lining the walls of basements to exclude damp.

Mineral rock asphalt is a natural limestone impregnated with natural bitumen. When the rock is quarried it is of a chocolate colour, very fine in grain and thoroughly and evenly impregnated with bitumen to the extent of from 6 to 14 per cent., the remaining properties being pure limestone. This rock is found principally in the Val de Travers (Switzerland), Seyssel and Montrottier (France), and Limmer (Hanover).

Mineral rock asphalt may be laid in two ways, viz., "powder-work" and "mastic-work."

Powder-Work is used for roadways. The material is prepared by grinding the rock to a fine powder, which is then roasted in a special plant, conveyed hot in steel waggons to the work, and spread on a solid concrete foundation. The powder is immediately beaten into position with hot iron rammers, and finished to a uniform

surface. The constant traffic of a busy thoroughfare soon renders this form of roadway very hard and durable.

Mastic-Work is used for roadways, pavements, roofs, and lining basements. The mineral rock asphalt is prepared by grinding and mixing with a certain proportion of pure Trinidad bitumen and other ingredients, after which it is moulded into blocks and stamped with the manufacturer's name. These blocks are melted in metal pots at the building, and "cooked" to the proper consistency, a certain amount of pure bitumen and fine washed grits being added. This work is spread in two layers, for horizontal work the joints being lapped. The material is spread with the aid of a wooden float. Being tough, it requires energy and kneading into position to exclude all air or gas bells which, if left in, would result in blisters. Mastic-work should never be executed in damp or wet weather.

For excluding damp from basements it is applied to the face of walls. This vertical work is slow and costly, but very effective if properly executed and properly jointed to a damp course of the same material extending under the whole area of the basement floor (see section on Damp Buildings).

Felts and Bituminous Roof Coverings.—A variety of *haired felts* and *fibre felts* are manufactured and supplied in rolls for building purposes.

For covering roof boarding, before the slating of the roofs is applied, the cheapest form of felt is suitable. These felts consist of a thin mat of vegetable fibre, impregnated with a solution of bitumen or tar.

A higher-grade material is manufactured, consisting of haired felt similarly treated with a coal-tar oil or bituminous solution. These haired felts are suitable for deafening floors by being nailed to the top or bottom of the joists before the application of the flooring or ceiling. They are also suitable for deafening purposes.

Prepared roofings include such materials as (1) "Aqualite" and "Plastique," composed of jute or canvas web, covered on both surfaces with pure bitumen; and (2) Vulcanised roofings consisting of vegetable fibre with some form of vulcanised bitumen or other substance which is calculated to exclude damp and resist fire. Such roofings are known as "Ruberoid," "Rok," &c. These are suitable for temporary or unimportant structures, where appearance is a matter of little importance. They present these advantages, that they may be rapidly and easily fixed by unskilled labour.

Timber for Building Purposes.—The study of timber, its growth, cutting, conversion, seasoning and characteristics, is a wide subject demanding long application and experience.

In most building work, particularly in cities, the timber required is procurable from the importer ready cut into the usual commercial sizes.

Defects in Timber.—The defects which should be looked for in timber are various. These defects are natural, and common to all kinds of timber. Such faults should be removed, if possible, during conversion.

In many classes of work a certain percentage of such defects as are mentioned hereafter is permissible, it being impossible to get perfect timber except at a very great cost. The following are common defects :—

Sapwood.—Of the defects in timber, the most serious is the presence of an undue proportion of sapwood. A great deal of sapwood is to be found in timber which is now on the market. This is due to the felling of immature trees. The sapwood is spongy in grain, showing large annual rings, and is generally of a blue colour. The sapwood in a board can be distinguished from the hardwood by the difference in colour. For constructional work or joiner work spongy or open-grained wood should be avoided. Sapwood is very liable to decay, and subject to attack by dry rot. Being immature it lacks strength in comparison with heartwood.

Shakes.—Shakes in timber are cracks due to contraction in the seasoning or drying of the timber.

Star shakes are due to the shrinkage of the wood on lines parallel to the annual rings. Heart shakes extend through or near to the heart of the tree. Cup shakes are caused by the partial separation of the layers composing the annual rings and are the most objectionable in timber, as they often extend for a considerable distance through the log. Experts can detect cup shakes by sounding the log. In converted timber, that is, timber cut into scantlings, cup shakes are not found in any great number, as in the process of conversion the defective parts of the log are discarded. Star shakes and heart shakes do not usually extend far into the log or batten.

Knots.—Knots in timber are the cross section of branches and shoots. These cannot be avoided, and are particularly numerous in red pine or redwood, less numerous in white pine, and of rare occurrence in good American yellow pine. Timber containing large loose knots should be avoided for structural work, but firm, undecayed knots, if not excessive in number or too large, are not objectionable.

Waney Edges.—" Waney edges " is a term which refers to a batten or " deal " having a splayed or rather slightly rounded corner or edge. This at once reveals the fact that the particular scantling

has been derived from the outer part of the tree, and is therefore almost entirely composed of the newest of the sapwood, or has been derived from a small and therefore immature tree. Such timbers should be discarded, but for rough or unimportant work they may be used if placed in an airy position, the " waney edge " being placed uppermost in the case of rafters or floor joists.

Characteristics of Good Timber. — Timber of good quality should be straight in the grain, free from large, or dead, or loose knots, shakes and waney edges. It should be thoroughly seasoned, uniform in colour, and as free from sapwood as possible.

Timber, when cut with a saw, should give out a fresh smell, should cut freely without clogging, and present a clear and firm surface, free from any dull or spongy appearance. A spongy appearance should lead one to suspect dead timber, that is, timber cut from a tree which had died before being felled.

In selecting timber it should be remembered that closely-set, dark-coloured annual rings indicate strength, whilst wide-set annual rings, and rings of a light colour, indicate the newer or sapwood. Good timber, when struck, should give forth a clear, ringing sound.

Grain of Timber.—A log of wood, cut into planks in a direction parallel with the medullary rays, presents a pleasing figured appearance known as " silver grain " when the timber is dressed. This method of converting timber into planks is not always economical, and is usually confined to the production of the better classes of wood, such as oak, mahogany, maple, walnut, &c., for fine joiner-work.

It is usual to cut timber for structural work so that as many cut battens, deals, planks or boards may be obtained from the log as is possible.

Dry Rot in Timber.—From the date of the felling of a tree timber is liable to attack by " dry rot,"* a disease which is usually most active when the timber is in position in a structure.

This disease, which is due to several fungi, especially *merulius lacrymans,* thrives most readily in situations which are unventilated and have a warm, damp atmosphere. The spores of the fungus may be in the timber before it is built into position, or they may be carried by wind, on joiners' tools, or by the temporary or permanent proximity of old infected timber.

* The term " wet rot " is applied to decay started in the standing tree; " dry rot " to " the form of decay induced in timber that is apparently sound when first used as constructional material." See *Journ. Board of Agric.,* Aug., 1916, XXIII., No. 5, p. 465.

A common situation in which this disease is found to be in a thriving condition is under ground floors, where the joisting and flooring boards are attacked, particularly if the solum of the building has not been cleared of vegetable matter and properly coated with tar, asphalt or concrete. It is obviously necessary thoroughly to ventilate, in such a manner as will create a through draught, all spaces under ground floors.

Spaces in roofs, enclosed by timber, are particularly objectionable, as in the event of a leakage and the presence of infected timber the fungus will rapidly take root and grow, ultimately reducing the timber to a powder.

The appearance of the fungus varies with the situation, stage of growth, and the facilities for promoting its growth. Sapwood, particularly in white pine, is very liable to the attack of the fungus. Those with experience of this disease can often detect the presence of dry rot in a structure by the unmistakably musty odour emitted by the fungus, and the atmosphere which it creates.

The fungus grows and spreads rapidly, in the early stages having an appearance somewhat like frost, and afterwards developing into a mushroom-like skin, which spreads over the surface of the timber. The fungus spreads over and into the joints of brickwork, plaster, masonry, &c., in its search for moisture with which to sustain its growth, but deriving nourishment only from the woodwork, which it destroys.

Resinous woods appear to be less liable to attack than white pine, and in every case soft, unseasoned sapwood is attacked.

It may be taken as an established fact that there is no cure for dry rot in timber which has been attacked. The only safe method is to cut out all affected parts and the parts adjoining. These should be carefully placed in a saturated sack and carried out carefully, without allowing any of the dust or spores to be blown about, and burnt in a fire in a situation away from all dwellings.

The replacement of woodwork should be carried out with perfectly sound, well-seasoned timber, and it is advisable to coat all surfaces of such timber with creosote oil, after having scorched the surfaces of all walls and remaining woodwork in the vicinity with a blow-lamp. Immediately after the application of the blow-lamp the surrounding woodwork should be thoroughly coated with a solution of water and corrosive sublimate, 2 per cent., but in no case weaker than 1 per cent. Great care must be taken in the use of this solution.

A safer but less effective method is to use a solution of copper sulphate.

The use of linoleum on wooden floors situated near the ground is a frequent cause of the growth of dry rot.

CONSTRUCTION OF WALLS.

The walling of a building should be looked upon primarily as a shelter from cold wind and rain. Its secondary duty is to support any upper floor and the roof as well as to form a support for stall divisions and stable or byre fittings.

It is obvious that a wall must not readily absorb moisture either from driving rain or by capillary attraction from the soil. The preliminary to building a wall of any description is to excavate a foundation track of the depth necessary to remove all top soil and humus, down to a bed of firm clay, sand, gravel, blaes or rock. The formation should be levelled or stepped into level stretches. For concrete foundations the track should be of the exact width of the concrete. The thickness and width of a foundation will depend upon the nature of the soil, but it is a good rule to make the thickness never less than 9 inches, and preferably 12 inches thick for the usual farm building. The width of a foundation may be from 9 inches to 12 inches more on each side than the thickness of the wall to give the necessary bearing area upon the soil. If concrete foundations are not used, which is rarely the case to-day, a foundation may be constructed in brickwork by forming scarcements. These are a stepped increase in the thickness of the wall, greatest at the base. They are open to objection, as being full of joints they give more readily than concrete to any soft part of the soil and cause a settlement in the building. Brick footings tend to draw moisture from the soil. Concrete foundations are always to be recommended as they are monolithic, resist the passage of moisture and are strong. Sometimes brick footings are built on a concrete foundation as shown in figure 91.

Upon the foundation, the top of which should be level, the wall is built and brought up all round the structure to a level surface to receive the damp-proof course about 4 inches above the ground level. In this case the stable or byre floor would be 2 inches above the damp-proof course, making the floor 6 inches above the ground if the site is level. The damp-proof course is important and must be executed with care. For details of construction refer to the section " Dampness in Buildings and its Prevention."

The material of which a wall is built depends upon the geological formations of the district. Brick walling is possible in most localities and is suitable, being regular in structure, smoother

on the surface than stone and lending itself to neat finish at door and window openings. Brick walls are built thinner than those of stone. The minimum thickness of a stone wall is about 20 inches, it being impossible to build thinner with satisfactory or economical results. With stone walling hewn stone finishings are necessary at doors, windows and corners which consequently increase the cost. Where stone is locally available and expense is not a consideration stone walls have much to commend them.

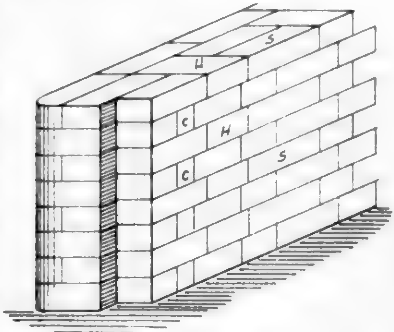


FIG. 50.—A 14 inch thick brick wall in Flemish bond showing door check and bullnose corner.

CONSTRUCTION OF BRICK WALLS.—As explained in the section on Building Materials, the standard brick is about 9 inches long by 4½ inches wide. These sizes determine the thickness of brick walling, which is usually designated as 4½, 9, 14 and 18 inches thick work, and so on. For most walls in animal buildings a thickness of 9 or 14 inches is sufficient. The bricks must be damp before use, and laid with the proper *bond*. This refers to the recognised arrangement and overlap of one brick

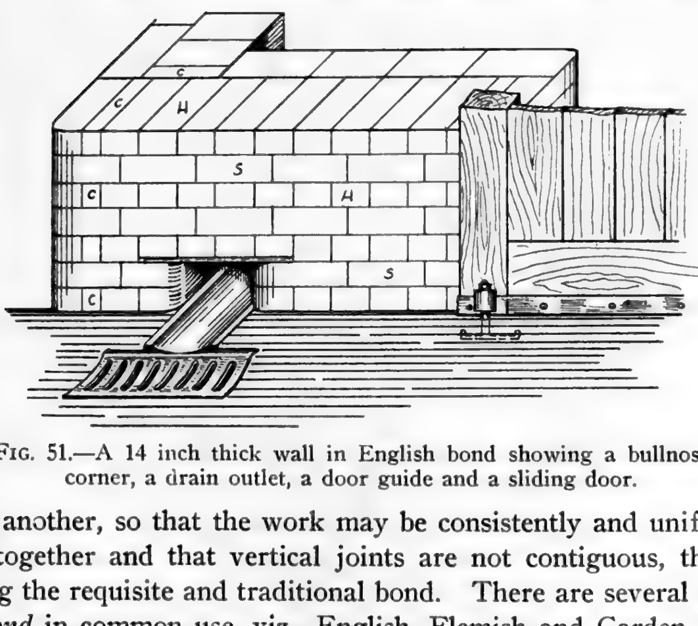


FIG. 51.—A 14 inch thick wall in English bond showing a bullnose corner, a drain outlet, a door guide and a sliding door.

with another, so that the work may be consistently and uniformly tied together and that vertical joints are not contiguous, thereby giving the requisite and traditional bond. There are several forms of *bond* in common use, viz., English, Flemish and Garden Bond. To understand a system of bonding the following terms must first be understood :—

Stretcher.—A brick laid on its bed with its greatest dimension parallel with the face of the wall.

Header.—A brick laid on its bed with its width parallel with the face of the wall and acting as an *inbond.*

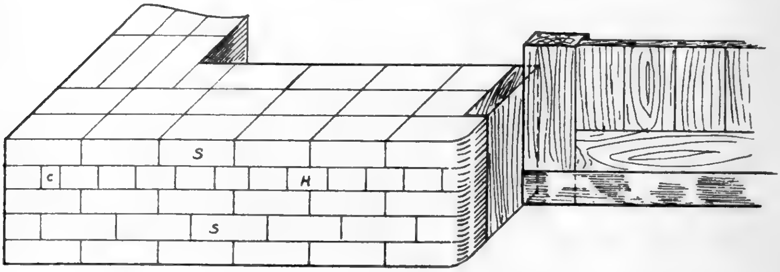


Fig. 52.—A 14 inch thick wall in Garden bond showing a hinged door with frame in check and a square external angle to the wall.
In the figures 50-52, H is a *header,* S a *stretcher,* and C a *closer.*

Closer.—The result of splitting a brick in half longitudinally. Used at the ends or corners of walls for the purpose of preserving the bond, see figures 50-52.

Bat.—A portion of a brick other than a closer used where necessary at the end of a wall to preserve the bond, *e.g.,* quarter-bat, three-quarter-bat and half-bat.

Stretching Course.—A continuous row of stretchers.

Heading Course.—A continuous row of headers.

English Bond consists of alternate courses of headers and stretchers showing on the wall face. This bond is the strongest, but takes longer to build than *garden bond.*

Flemish Bond consists of alternate stretchers and headers in each course showing on the wall face. The main feature of this bond is its effective appearance for domestic work.

Garden Bond consists of three succeeding courses of stretchers and one course of headers showing on the face throughout. This is the bond in most general use for commercial and agricultural buildings. It presents fewest difficulties in building, and is speedy and satisfactory. See figures 50-53 for illustrations of bonds.

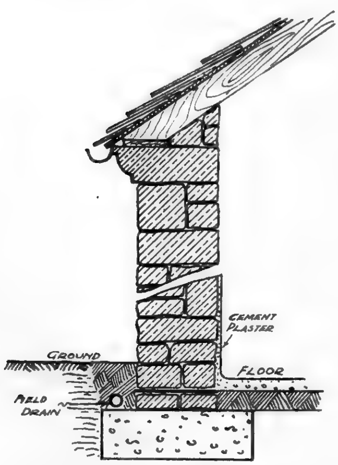


Fig. 53.—Section of 22 inch thick stone wall showing bond stones, floor slightly below the ground with damp-proof course and field drain surrounded by dry stone in-filling to exclude damp.

In building brick walls care must be taken to select the best bricks for the face, avoiding porous, discoloured and chipped bricks. The work must be levelled and plumbed carefully as it proceeds. The walls should be carried up regularly without stepping-back. The mortar is important. Cement mortar as described in the section on Building Materials is best for brickwork, being stronger and more impervious to moisture than lime. The faces of walls may be pointed as the work proceeds. This method results in a more durable face than is the case with pointing executed after the walls are built. Walls built in lime mortar should be raked out and pointed with cement mortar after completion.

For the construction of hollow walls see the section on "Dampness in Buildings and its Prevention."

The joints of all brick walls should be grouted up fully with cement mortar and water as each course is completed.

Stone Walls. — The methods of building stone walls vary slightly with districts, and consequently with the local materials. Certain classes of stone such as whinstone and Kentish rag cannot be treated in the same manner as flat bedded stones such as stratified freestone.

A stone wall may be built as random rubble, squared rubble, or coursed rubble. In every case the principle is the same, viz., the observation of building on the natural bed, bonding the stones on a principle similar to that in brickwork and, most important, the introduction of through-going headers or bond stones, one to every superficial yard of walling.

ROOF CONSTRUCTION.

It is apparent that in the past the most scanty consideration has been given to roofing animal habitations. Usually the material most available has been used. It is obvious that the type of roof and roof covering best for its purpose is the cheapest in the long run.

The section on Air and Ventilation emphasises the importance of the open roof for animal habitations. The exclusion of the loft is recommended as desirable. Particularly for cow byres and for stables and piggeries it is important that the roof trusses should form the least obstruction to air and light, and that, if possible, they will present the smallest of surfaces for the lodgment of dust. To meet this requirement the Scottish method of roofing, with rafters and ties set at 18 inches or 20 inches centres, is to be discountenanced.

All roofs consist of supporting trusses and a roof covering, to

which must be added the necessary roof lights, outlets, ventilators, gutters, &c.

A roof truss may be composed of wood or steel arranged to form a rigid support for the purlins and covering. The trusses, resting upon the wallheads and set at suitable centres, carry the purlins, to which are fixed the boarding or corrugated iron.

The various forms of roofs are illustrated in figures 54-56, where the names of the members are shown. It should be noted that the width of the building to be covered, together with the kind of covering adopted, will largely determine the type of roof. For the necessary warmth in winter and coolness in summer, it is emphasised that a roof having either plain or grooved and tongued boarding over its whole surface is most desirable, no matter how covered.

Roofing composed of steel trusses, wood purlins and boarding, covered with felt and slates, possesses all the qualities desirable for a stable. This form of construction is warm in winter and cool in summer. The covering is durable and easily repaired. The steel trusses present the smallest surfaces for the lodgment of dust, and the minimum obstruction to the passage of air and light. The same type of roof with wood trusses comes next in favour. A roof of similar construction, but lighter in its members, covered with one or two thicknesses of bituminised felt or canvas fixed properly to the boarding, is permissible where slates are not available. If cost is a serious consideration, a very much lighter structure of the same type, but

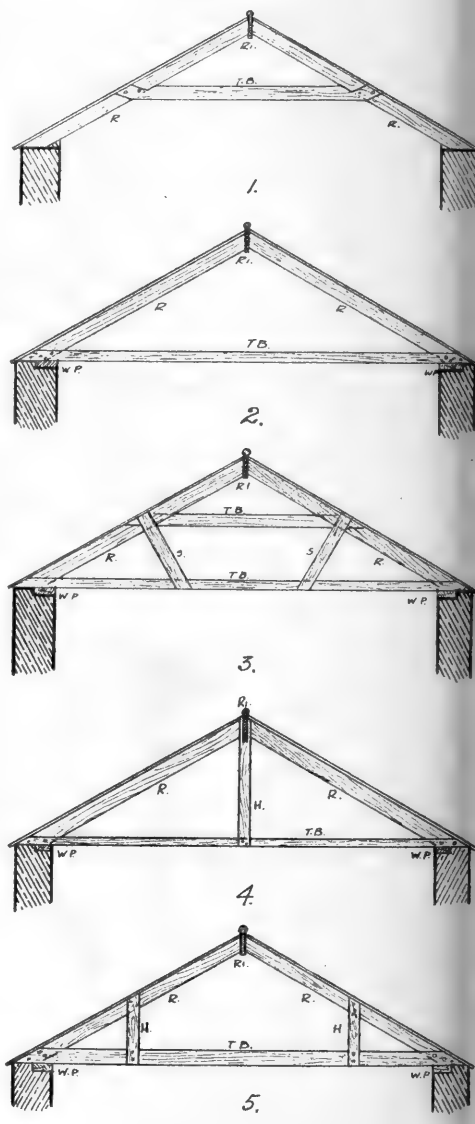


FIG. 54.—Couple Roofs.

NDEX TO ROOFS.

FIGS. 54, 55 and 56.

Couple Roof with Collar Tie.

. Couple Roof with Lower Tie.

Couple Roof with 2 Ties and 2 Struts.

Couple Roof with Centre Hanger.

Couple Roof with 1 Tie and 2 Hangers.

King Post Roof.

Queen Post Roof.

9 and 10. Three types of Steel Roofs with wood Purlins for boarding and slates.

R. Rafter.
R1. Ridge.
C.R. Common Rafter.
P.R. Principal Rafter.
T.B. Tie Beam.
S. Strut.
P. Purlin.
H. Hanger.
K.P. King Post.
Q.P. Queen Post.
S.B. Straining Beam.
W.P. Wall Plate.

Members subject to *compression* are indicated by "C," and to *tension* by "T."

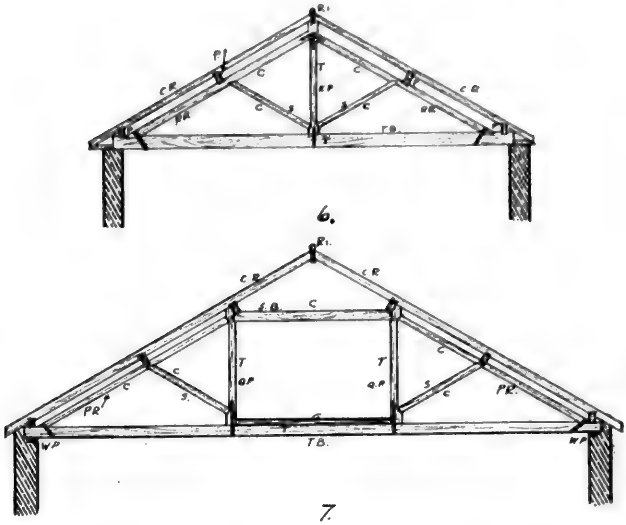


FIG. 55.—Framed Roofs.

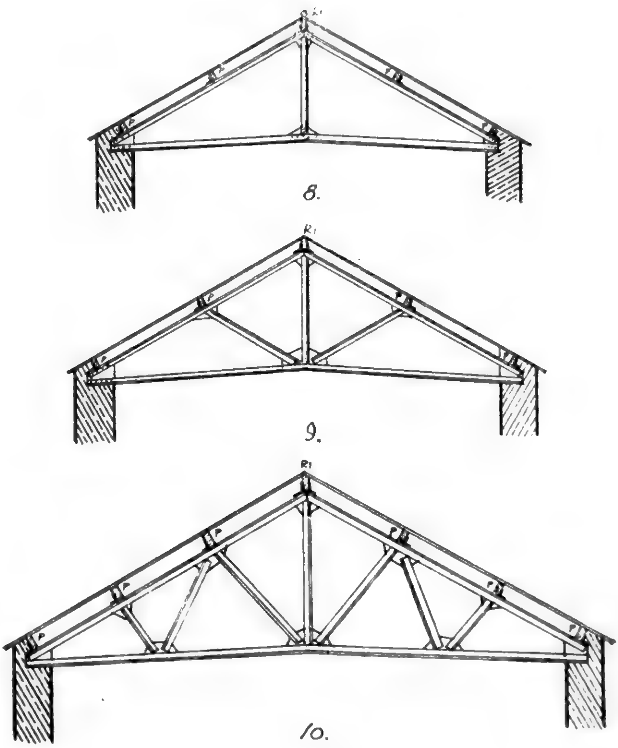


FIG. 56.—Steel Trusses.

covered with corrugated iron, may be used. This covering will dispense with the costly boarding, but it must be borne in mind that it makes the housing cold in winter and hot in summer. Corrugated iron roofing, however, is suitable for cattle courts, piggeries, manure pits, cart-sheds, &c.

FLOORING.

The flooring of buildings intended for the housing of animals has always been a matter of difficulty and, at the present time, opinions are divided as to the most suitable method. There are, however, certain requirements that must be complied with if animals are to be housed under hygienic conditions.

The essential requirements for a hygienic floor are that it be non-porous, be capable of being easily cleaned and quick drying; it must be non-slippery, durable, free from damp and be comfortable for the animals. Since the majority of animals are kept for profit and not for pleasure, the question of expense has to be considered.

Owing to the fact that animals void their fæces and urine where they stand it is necessary that the floor be composed of some material that will not absorb moisture, otherwise the flooring and the subsoil would become permeated with urine, &c., and be constantly damp and cold, and the air of the building would be vitiated with the products of decomposition which, if not actually causing disease, would at least lower the vitality of the animals and render them more susceptible to disease. Damp floors and damp walls are marked predisposing causes of illness and general debility. A floor that does not soak in water and which readily dries after it has been flushed lasts longer than one that retains moisture.

Slippery floors have been responsible for many accidents to animals, and especially to horses and cattle. The more impervious a floor is to moisture the harder and denser is its structure, but unfortunately the surface of such a floor is smoother than one which is less compact. An even floor with a smooth surface becomes polished with the friction of animals passing over it; dirt, especially of a greasy nature, fills up the small pores on the surface, making it still smoother until it becomes polished in much the same way as does wood that is dressed with wax and turpentine. A smooth hard surface is slippery to shod horses and a smooth wet surface is dangerous to cattle, especially if it is dirty.

Accidents to horses and cattle on slippery floors are mainly due to the passage at the rear of the stalls being too narrow, to turnings near or at the doorways being too abrupt, and also to animals being

hustled to and from a building. A smooth impervious floor is not dangerous if it is kept clean and if the animals are not hurried or frightened.

For both economic and hygienic reasons a floor must be durable. One that has been badly laid wears unevenly and subsides in patches. If made of concrete on an unsatisfactory foundation it cracks and wears into holes, which give lodgment to water and dirt and are a constant nuisance.

For a floor to be free from damp it is necessary that it be at least 6 inches above the surrounding ground. Should, however, the ground be so sloping that the floor must of necessity be below the level of the outside at any part, then provision must be made for keeping out the damp by the formation of a "dry area" or a special damp-proof course. If the floor is on the same level or below the outside ground it is always difficult to keep out the damp, and the doorways in wet weather are invariably wet and dirty. A low-level floor is much more difficult to drain than one that is raised.

Of the materials commonly used for the flooring of animal-houses, cement concrete is undoubtedly the best. If properly laid and of good composition it is as durable as any other flooring, more impervious than most, and relatively as cheap. The bottoming of a floor is the same whatever material is used to cover it, and since the durability and, consequently, the hygienic condition of the floor depend very largely upon the nature of the bottoming, particular attention is paid to it.

To ensure a satisfactory and lasting floor the earth must be cleared away to the necessary depth, which will vary with the nature of the soil, levelled off and well rammed until it presents a hard, even surface. Having prepared the ground, a layer of stones or bricks broken to pass through a 4-inch ring is then spread to a depth of 5 or 6 inches, rammed compactly and finished to a proper level on top. It is important that this foundation should be well constructed, for if badly laid it causes the floor to sink and crack. On this bottoming is laid a 3 or 4-inch thick cement concrete floor, composed of one part Portland cement, four parts gravel, broken stones or bricks and two parts sand, the whole being well mixed together with clean water. The concrete is then well beaten down, levelled off with a wooden float, which leaves a slightly rough surface, and left to set. It may be brushed with a stiff brush after it is levelled to give a somewhat rougher face. In order to give additional foothold, the cement concrete may be grooved in straight lines, herring-bone fashion, or checkered (see fig. 57). The grooves

should be at least half an inch deep and should, as far as is practicable, run at right angles to the direction usually taken by the animals when entering or leaving the building. Checkered grooving is not to be recommended as such a floor is difficult to clean. Should a finer and more durable surface be desired than is given with cement concrete, the upper inch may be composed of two parts crushed granite and one part Portland cement.

While cement concrete undoubtedly forms the best flooring for cow-sheds, piggeries, &c., some are of the opinion that it is too slippery in stables for horses owing to its smooth surface and to the fact that even when well grooved the grooves in course of time become shallow and worn away by the friction of the horses' shoes. Nevertheless, cement concrete has been found to give complete satisfaction in commercial stables for heavy draught horses.

Other more or less satisfactory paving materials are causeway setts, vitrified paving bricks, and bricks made of mineral rock asphalt. Causeway setts may be either of whinstone or granite. They are made in various sizes to suit a variety of purposes and local customs. In Scotland the usual size is from 9 inches to 11 inches long, 4 inches broad on the face, and from 6 inches to 6½ inches thick. In England, and particularly in the Liverpool district, 4-inch cubes are common. Another favourite size in some districts is from 8 inches to 10 inches long, 3 inches or 4 inches on the face, and about 5 inches deep. For the best class of work, the causeway setts should be laid in a cushion of sand on a concrete bed from 4 inches to 6 inches thick. The joints should be grouted with sand and cement, or with pitch. Sometimes the joints are grouted for about two-thirds of their depth, the remainder being filled in with pitch. Granite setts give a good foothold when first laid, but are inclined to become slippery with wear.

Vitrified paving bricks (see Building Materials) are laid in the same way as setts. They wear very well but are always slippery. They should be grooved to give foothold and the groove in each brick should be fairly deep and wide, a shallow narrow groove serving only to collect dirt. The bricks should be placed so that there is a continuous uninterrupted line of grooving.

Mineral rock asphalt makes a warm, non-slippery floor, but it is expensive for ordinary use.

Common building bricks, though frequently used in byres and piggeries, are too porous to make a satisfactory flooring material, and being comparatively soft they wear very unevenly. They are cheaper than vitrified paving bricks and are less slippery. If used, they should be placed on their edges and be set in cement.

Wood, in one form or another, is occasionally met with forming in part the flooring of an animal-house. It is scarcely necessary to say that wood is quite unsuitable for this purpose. Even hard-wood blocks absorb water and so also do creosoted railway sleepers.

CONSTRUCTION OF STABLES FOR HORSES.

The planning and fitting of a stable naturally depend upon the number and class of horses to be housed, but the hygienic requirements remain the same. Simplicity should be a ruling factor in construction. Plainness of internal fittings does not necessarily mean ugliness, neither does a high degree of decoration always imply beauty, and it certainly seldom conduces to hygiene.

Where accommodation is to be found for only a few horses, the stalls are most convenient if placed in a single row with the horses' heads turned toward the wall. For a large number of animals a double stable with two rows of stalls is more convenient and less costly to build. The horses should be placed facing the walls with a passage running down the centre of the building between them. The stalls should not be constructed so that the animals face each other, nor should they be placed in transverse rows across the building. No more than two rows should be allowed under one roof. The requisite air-space per head is a *minimum* of 1100 cubic feet for heavy horses and 550 cubic feet for animals of medium size. Twice or three times this space may be given with advantage (see page 90).

Stalls.—For cows the superficial area of a stall has to be reduced as much as possible for reasons which are explained on page 167. With horses no such restriction of space is necessary, and consequently stalls can and should be built sufficiently large to allow freedom of movement coupled with safety from accidents. Obviously, a stall built for a pony will not be suitable for a Shire horse, and some consideration should be given to the type of animal the stall is expected to hold. Fineness in allotment of space is neither necessary nor desirable, as is the case with cows, and it is better to provide stalls of a large size, since they can accommodate small horses while the small size is useless for big ones. The object of providing separate stalls for each individual horse is that each animal may rest and feed in security and comfort, and free from the annoying attentions of his neighbour. The length of a stall from the facing wall to the heel-post of the stall partition should be 13 feet for large horses of the Shire type and 10 feet for the average horse of the light draught type. Stalls are almost invariably made

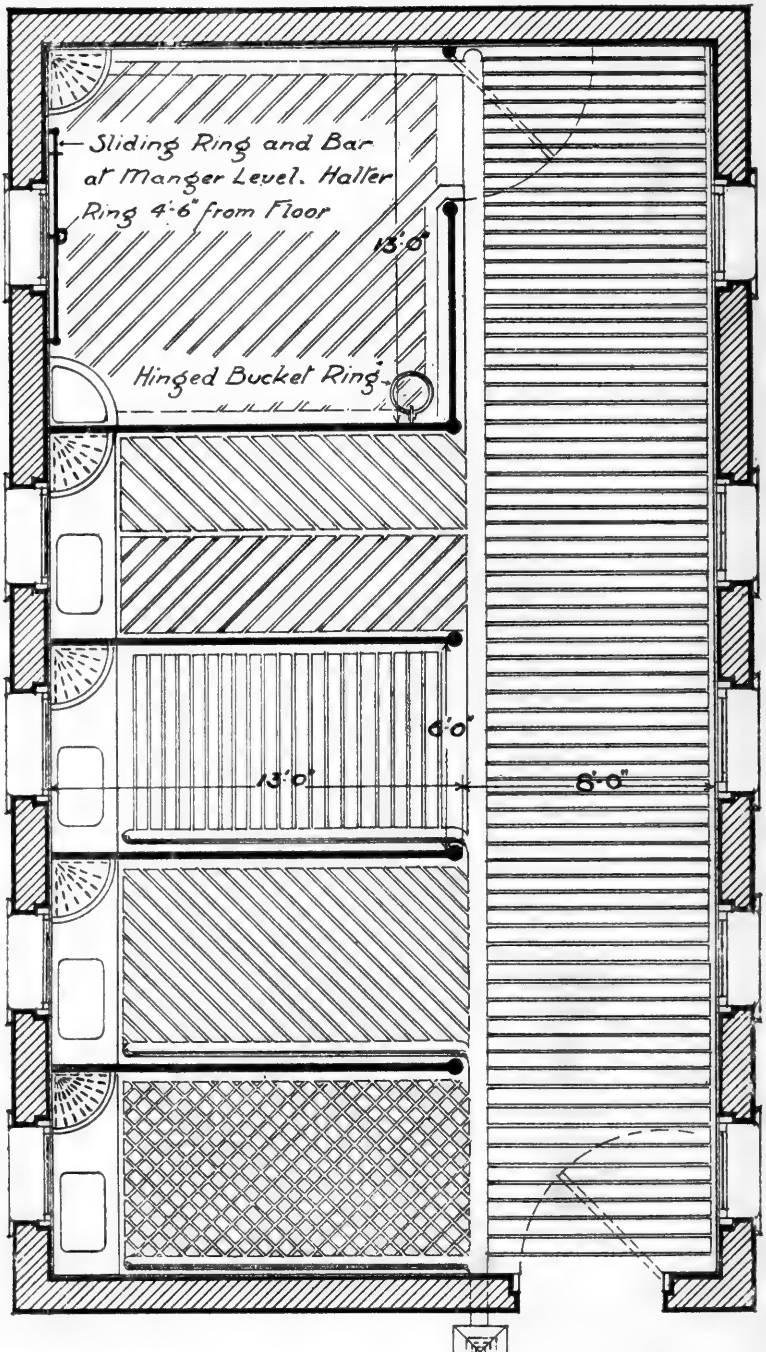


FIG. 57.—Plan of a single stable for heavy draught horses showing various forms of cement floor grooving of which the herring-bone type is best. The bucket ring should be fixed to the wall. The stable door may be made to open outwards or as shown.

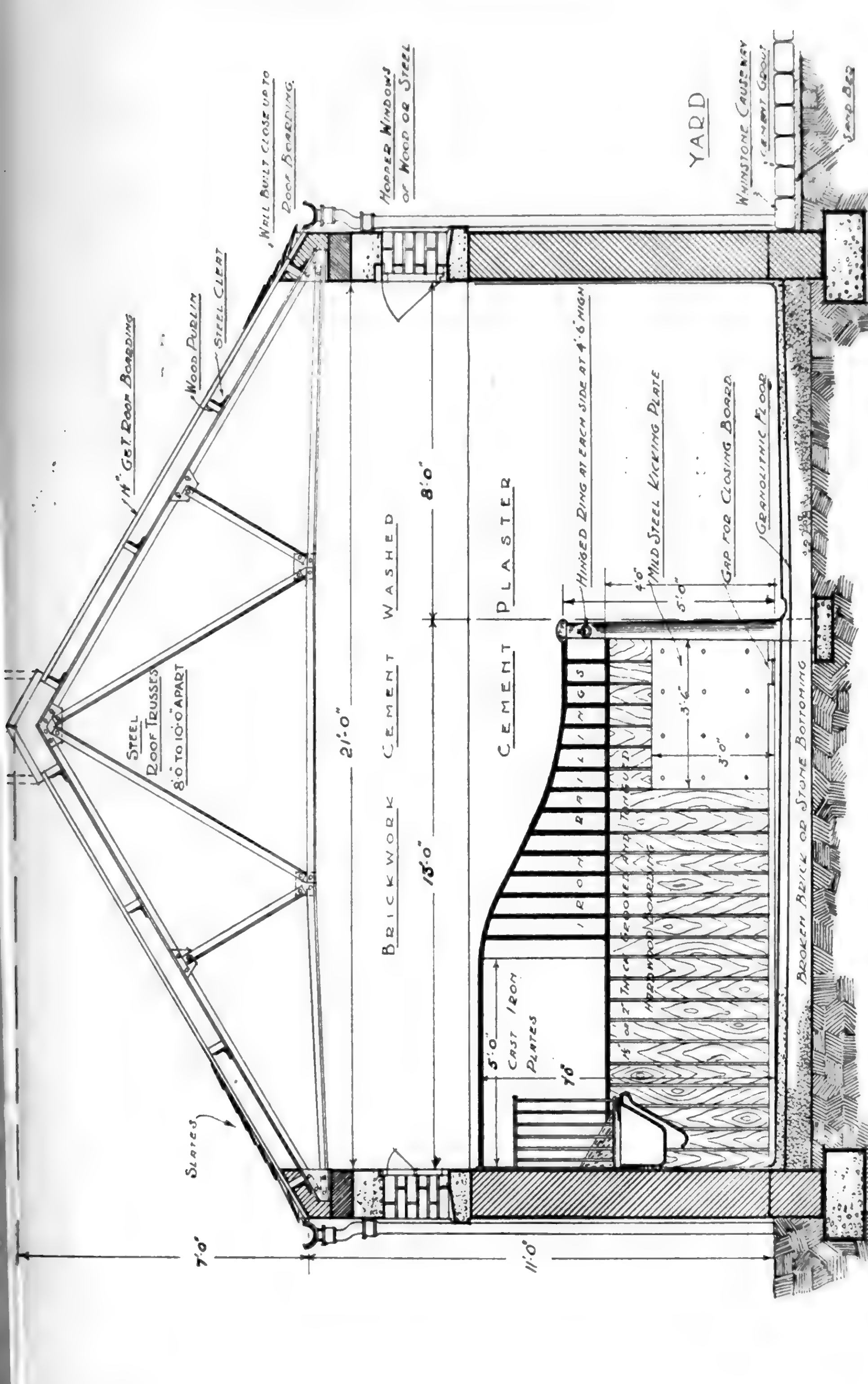


FIG. 58.—Section of a stable suitable for heavy draught horses.

too short. The length should be such that it is impossible for one horse to kick his neighbour when both are standing back in the stall. The width of a stall for large horses needs to be 6 feet 6 inches if the animal is to lie down in comfort, and to permit of his being turned round in the stall when the head-rope is loose. A breadth of 6 feet will be found ample for light draught and riding horses.

Passage.—The passage at the rear of a row of horses or between two rows of horses in a stable should be sufficiently wide to permit of the animals turning comfortably when entering or leaving their stalls. Usually this passage is much too narrow; it should not be less than 8 feet for a single-stall stable and 15 or 16 feet for a double stable. In many single stables it is no wider than 5 feet.

The height of the stable must be such as will give ample air-space for the animals, but yet not so high that ventilation is interfered with by the foul air becoming cooled and condensed before it gets an opportunity to escape. If the stable has a closed roof, that is with a loft, stable or other room above, the height from the floor to the ceiling should be 14 feet, but not more. A little less will be adequate for the smaller horses.

If the air-space be calculated from these dimensions, that is, stall 13 feet from wall to heel-post and 6 feet 6 inches wide, passage 8 feet wide, and height of building from floor to ceiling 14 feet, it will be found to be 1910 cubic feet. From this must be deducted 20 cubic feet for the space occupied by the horse, leaving a net air-space per animal of 1890 cubic feet. While this might with advantage be increased, the present cost of building is such that it must be considered sufficient. The floor space of a stable having these dimensions is 136 square feet per animal, or one-fourteenth of the total number of cubic feet of air-space.

If the stable is open to the roof, that is without any other room above it, and this is a form of construction much to be preferred to a closed roof, then not only will the total air-space be greater, but the ventilation will be more efficient. The height of the walls with an open roof should be approximately 11 feet, and with a single stable having an inside width of 21 feet, the height of a slate-covered roof from the ridge to the eaves would be 7 feet.

The air-space of such a building, after making a suitable deduction for the space taken up by the horses, will be 1957 cubic feet per head.

Ventilation and Lighting.—The ventilation should be planned as recommended in the chapter dealing with the subject. Windows of the Sherringham or hopper type are excellent for lighting and ventilating stables. Where there is accommodation over the stables

they will have to serve both as inlets and outlets, unless there are extraction tubes for the foul air as have been described on a former page. The windows must be of such a size as will give not less

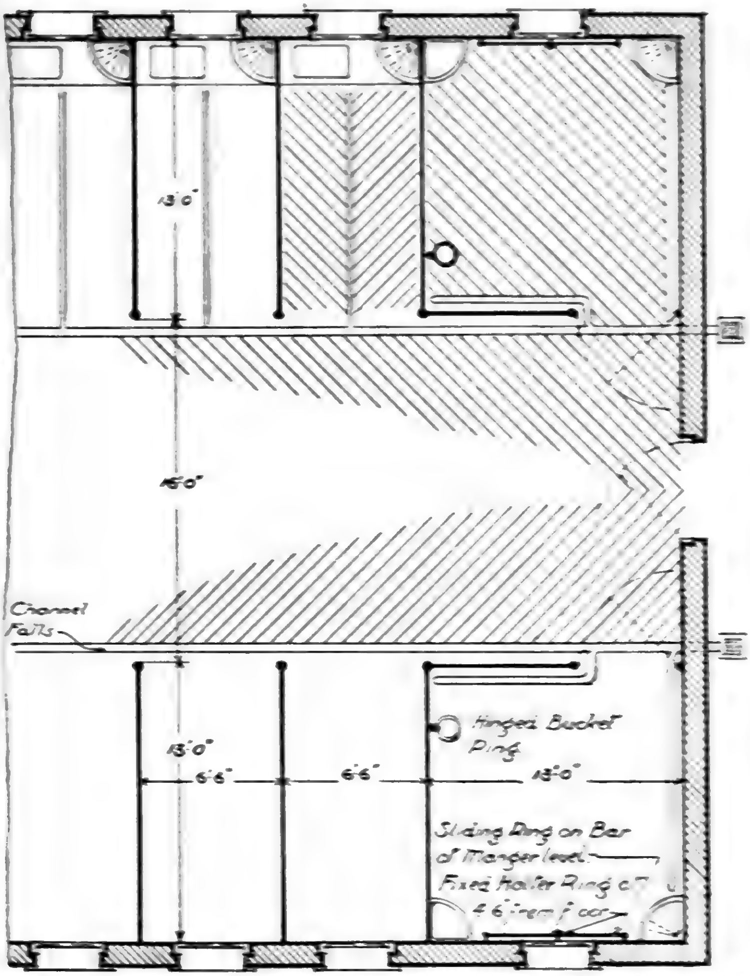


FIG. 39.—Plan of a double stable for heavy draught horses. The bucket ring in the loose box should have been shown fixed to the end wall. The stable door may open outwards if desired.

than 3 square feet of glass per animal, and must open so as to admit the requisite amount of fresh air on the one hand and to allow for the escape of the foul air on the other hand. The bottom of the windows must be 7 feet from the floor. Windows must be built without inside ledges as they accumulate dust and dirt. One window should be placed opposite each horse, or at least one between every two stalls. Outlets at the roof ridge may be extraction cowls, louvre boards, or the apex of the roof may be open as in Findlay's system.

Flooring.—The flooring of the stalls and passages may be of vitrified paving bricks, Portland cement concrete, or mineral rock asphalt. Flooring has been discussed on page 142, and it is only necessary to say here that one of the above materials should be

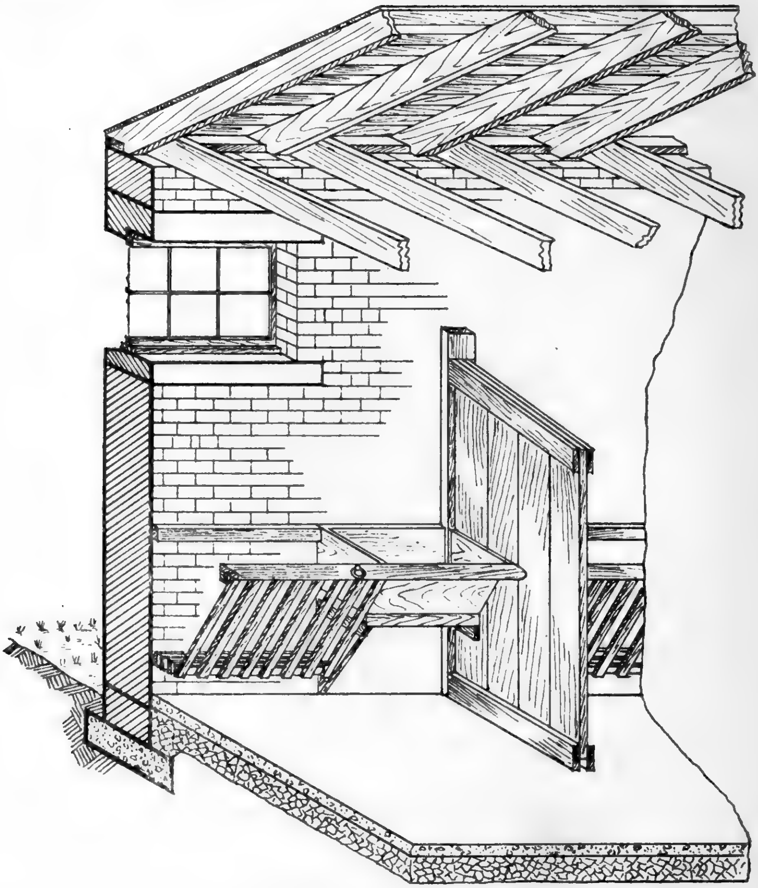


FIG. 60.—View of a horse stall commonly found in farm buildings. Bad features are the close couples which accumulate dust and retard ventilation, a fixed window with inside sill, and wood stall fittings.

chosen. The floor of each stall must be given a slight slope, of not more than 1 in 70, from the front to the urine channel, and may with advantage be grooved herring-bone fashion as shown in figure 57. The passage must also be laid with a gradient sufficient to carry wash water into the channel. The channel itself, as has been explained in the section dealing with sanitation, runs down the length of the building immediately behind the stalls and passes through a hole in the wall. It should be quite shallow.

Walls.—The inside of the stable walls must have a smooth

hard surface so that they do not give lodgment to dirt and dust and are easily cleaned. It is quite unnecessary to go to the expense of lining the walls with glazed tile or of having them built with glazed bricks, but glazed tiles or bricks of a neutral tint (dead white is not suitable) may with advantage be placed over the mangers. If the walls are finished with a face of smooth hard cement to a height of 7 feet from the floor and above that well pointed and washed over with cement they will satisfy hygienic requirements.

All corners and angles such as are formed at the junction of wall with floor, &c., must be filled in with cement so as to facilitate cleaning.

Doors.—The doorways, of which there should be two in a large stable, must not be less than 4 feet in width, while 4 feet 6 inches is preferable so as to lessen the risk of horses bumping themselves when entering and leaving the stable.

The minimum height of a stable doorway so that horses can pass through it with safety is 8 feet. A low doorway sooner or later means that a horse bumps his head. All stable doors should be made in two parts cut transversely, the lower part being 4 feet 6 inches high and the upper 3 feet 6 inches. When necessary, as on hot, close days, the upper part can be fastened back to the outside wall and left open. All door fastenings must be of the safety type so that when the door is opened the bolt recedes into the door. Ordinary latch fastenings have been responsible for many accidents arising from horses getting their harness caught on the latch when the door has been left half open.

Stall Divisions or "Travises."—Stall divisions are for the purpose of separating each horse from his neighbours. As working horses require as much rest and quietness as it is possible to give them during their stabled hours, stall divisions ought to be constructed with this end in view. For a horse to rest and feed at ease it is imperative that he be shut off from his neighbours so that one cannot see or interfere with another. The necessary height and length of the partitions depend upon the size of the animals.

As has been stated, 13 feet is a desirable length from wall to heel-post for horses of the Shire type, while 11 feet 6 inches will do for the average contractor's horse. The height at the rear part of the stall need not be greater than that which will prevent such an accident as a horse getting his leg caught over it. Five feet will be found sufficiently high for this purpose. It is not advisable to make the partition higher than necessary, especially if it is made of solid planks throughout, because the less partition there is the more free is the ventilation. At the head of the stall the partition must

be at least 2 feet higher to prevent adjacent horses from worrying each other by poking their noses over the top. The partition may therefore fall away from 7 feet at the head to 5 feet at the rear of the stall.

Stall divisions are usually made of wood, and the boarding

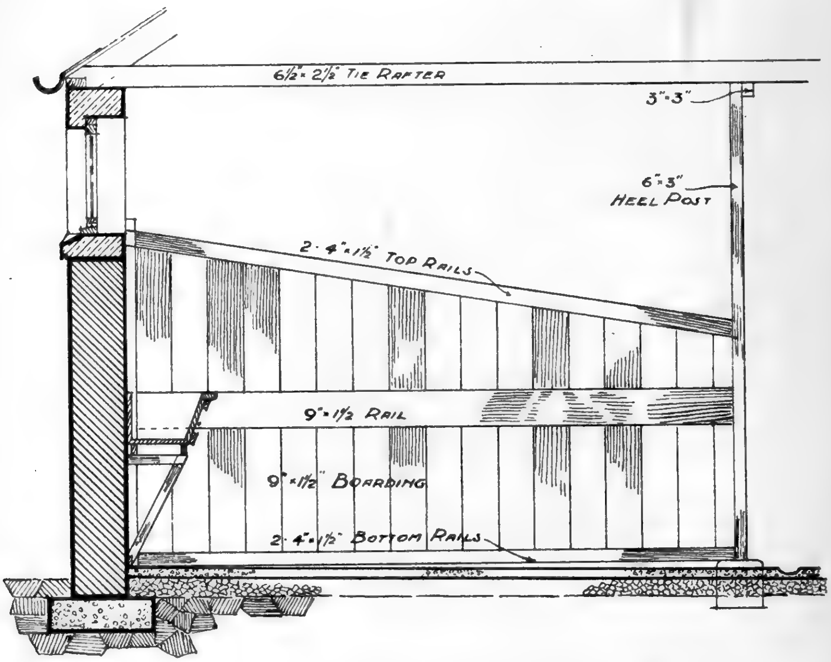


Fig. 61.—Section of a stall shown in figure 60 with all-wood fittings.

should be at least 1½ to 2 inches thick. It is conveniently made in 6 inch widths. Hard well-seasoned wood such as teak is preferable to moderately hard woods such as pitch pine or red pine. Soft or moderately hard woods wear badly and require constant repairs. They also become rough and consequently are difficult to clean and disinfect when the need arises. Stall partitions have to withstand much hard usage, being subject at times to great stress from kicks. The rear part of the stall should, therefore, be protected by mild steel kicking-plates 3 feet 6 inches wide and 3 feet high, securely fixed to the boarding.

With travises of the type shown in figure 58, the boards are placed vertically and fit into grooves in the metal at the top and bottom, a space being left to insert the last board which is then closed with a metal plate. Travise boards are sometimes held together with metal tongues.

It is not necessary to make the whole of the partition of wood. If the upper part consists of iron railings, as in figure 58, the stall

is less confined, more freely ventilated, and the horses are more readily seen. Four feet is a sufficient height for the boarding. The iron rails above the boarding should be of the simplest design. All ornamental and scroll work is to be condemned. At the head of the stall the iron rails ought to be discontinued and that space filled in with cast plating for a width of 4 feet from the wall for medium or small sized animals and for 5 feet for larger horses. This plate prevents the horses seeing one another and worrying at feeding time. The rear support or heel-post of the stall division as well as forming part of the framework of the travise may, in addition, act as a column to support the floor above. In either case a circular iron pillar having a smooth face and free from projecting bolts is to be preferred to a wooden post.

The pillar should be finished off as shown in figure 58, and not be surmounted with a ball of iron as is often done. Any projection above the travise of this nature is liable to catch the harness or bridle or cause the horse to bump his head when he is turned round in the stall. Such a ball serves no good purpose, but is supposed to be ornamental. The pillar should be well sunk into the ground, have a broad baseplate and be imbedded in cement concrete. No brackets or hooks for the purpose of hanging up harness ought to be allowed on the heel-post. A ring on each side for the pillar chains should be placed about 4 feet 6 inches from the ground as shown in the figure.

It is possibly an advantage for the travise boarding to stop short about an inch above the ground. This allows some current of air to pass along the floor and under the travise, thereby facilitating drying and keeping the low ends of the travise boards clear of the damp bedding and wash-water. There are three objections to this method, the risk of shoe heels being caught in the space, the weakening of the whole partition and the fact that dirt accumulates there.

Bails (from O. Fr. *baille,* a barrier).—In place of the complete stall division above described, modified ones in the form of swinging planks or poles are sometimes used. These are known as bails. They are chiefly used in military, temporary and, to a less extent, in commercial stables. There are various patterns in use. The simplest bails are in the form of an iron bar or wooden pole. This type is much favoured by the military authorities. Wooden plank bails are usually made of elm or oak 2 inches thick and 12 inches in depth, the front 3 feet or so being covered with iron sheeting or zinc to preserve the wood from horses biting it. Plank bails are sometimes fitted with a subsidiary piece about 4 feet long and 1 foot

in depth hanging from the rear and forming a "kicking-piece;" this offers some protection from kicking horses. Bails are hung by a short length of chain from the manger in front and the heel-post behind. They have, therefore, a certain amount of lateral movement. Pole bails usually hang about 3 feet from the ground. All bail chains should be secured with safety catches so that they can be released quickly owing to the frequency with which animals get hung up on the bails.

Advocates of the bail system of separation claim for it that ventilation is more free than with closed partitions, that all horses are visible when one enters the stable, and that there is economy in construction and greater facility in cleaning and washing out

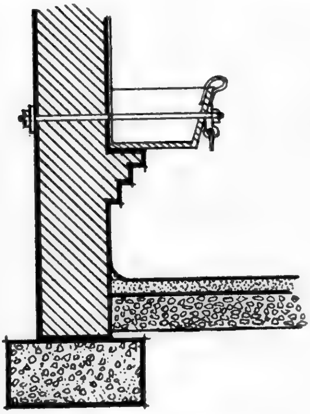


Fig. 62.—Section showing a substantial type of wood manger with corbelling and tie bolt.

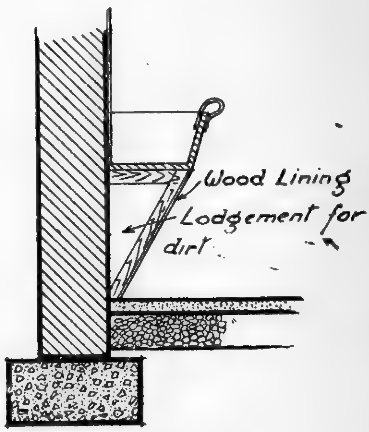


Fig. 63.—Section showing a wood manger.

the stable. The disadvantages of bails are numerous. Horses frequently get astride them, especially during the night, and when in this position the inside of their legs and groin get damaged, sometimes seriously. A method sometimes adopted to lessen the possibility of damage is to cover the suspending chains with leather or to fix a large smooth ball round the chain where it joins the bail. Horses are liable to get their legs over the bail if it is hung too low, and if it is hung too high they damage each other's legs by kicking under the bail. However bails are constructed, or at whatever height they are hung, kicks resulting in injuries ranging from a mere skin abrasion to a broken leg are always possible. The price of one good horse will pay for several proper partitions. A very serious disadvantage arising from the use of bails is that many horses are prevented from lying down. In a stud of heavy cart horses well known to the author a comparatively large number have

to be provided nightly with " sitting-ropes " tied to the heel-posts. Part of the stables is fitted with bails and part with stall partitions. Young horses which have been put in the bail stables have been so frightened by having their feet and legs tramped on when lying down that they have become afraid to do so and have never regained confidence even when put into proper stalls or loose-boxes. Horses need rest and comfort when in the stable; with bails they get neither.

Mangers.—The manger fittings in common use range from the plain wooden trough for holding the grain and chaffed fodder with a wood sparred hay rack to the cast-iron mangers and racks designed on hygienic lines. Wood mangers and hay racks are cheaper at first cost than those made of iron, and for that reason they will continue to be used where the initial outlay has to be considered. They are not hygienic, and are most unsatisfactory owing to the constant repairs necessary. It is impossible to keep wooden mangers clean, and if bran in the form of a mash is used in them they soon become sour and offensive, objectionable to the horse which has to feed from them and to the attendant who is supposed to endeavour to keep them in a usable state.

If wood mangers are used they should be made of elm or oak 1½ to 2 inches thick, and be about 18 inches wide at the top, 9 inches wide at the bottom, and about 30 inches long. The front board should slope inwards to reduce the chance of horses bumping their knees. Twelve inches is a sufficient depth for a manger. This will hold a feed of grain and chopped fodder without chance of its being tumbled out by the animal searching for the grain portion of the feed. The front or breast board of wood mangers ought to be protected by a carefully formed iron or mild steel plate fixed as shown in the illustration. This bent plate is for the protection of the woodwork against " crib - biting." Zinc is often recommended as a covering for woodwork, but unless the zinc is unusually thick it will soon become bitten through by crib-biting horses and present a source of injury by reason of the sharp, jagged edges. Unless zinc again becomes a cheap commodity, the thickness necessary to resist the attentions of a crib-biter would be an expensive item of upkeep. The method shown in figure 62 is suitable for the construction of wood mangers.

Iron is undoubtedly the most suitable material for all manger fittings. If properly made they are easily cleaned, are practically everlasting, and seldom, if ever, need repairing. There are many excellent makes on the market, designed with a view to utility and hygienic requirements. They must be large enough to hold with ease a full feed of grain and chopped fodder.

Objection has been made that they are too small for use in commercial and farm stables. This is, however, no valid excuse for their rejection, as manufacturers make them of any sizes. Satisfactory inside dimensions are 30 inches long by 14 inches wide by 12 inches deep, narrowing towards the bottom. A roller-bar fixed across the manger a few inches from each end effectually prevents horses from tossing the food out in the search for grain. An overhanging lip which is sometimes recommended to prevent the tossing out of fodder is undesirable, as it interferes with the cleaning of the manger, and is quite unnecessary if the bars are used and the manger sufficiently deep.

If the top of the manger is placed 3 feet from the ground it

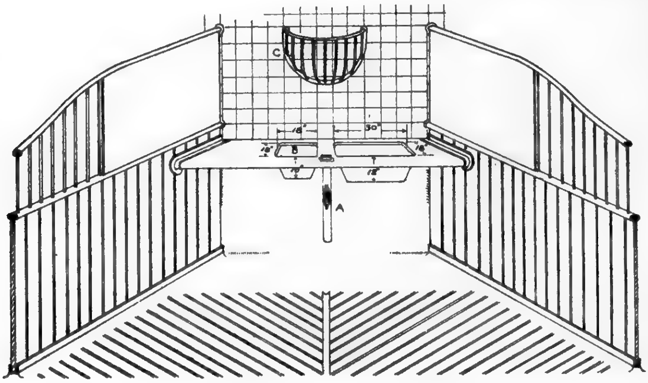


Fig. 64.—View of a stall with cast-iron manger fittings. A. Enclosed head-rope guide. B. Water pot close to manger, which is a bad feature. C. An overhead hay-rack which always should be condemned.

will be found a convenient height for the average horse, high enough to prevent a horse getting his feet into it, unless under extraordinary circumstances, and low enough to feed from it with comfort, while 3 feet 6 inches or more is required for Shire horses. The under portion should slope away from the top to reduce as much as possible the risk of bumped knees. The boarding in of part of the space under the manger, as shown in figure 63, is not to be recommended. Although it may offer some protection against bumped knees, it harbours dirt and provides lodgment for vermin. The front of the manger, if broad and rounded off, reduces the chances of crib-biting. The inside of the pan should have the corners and angles rounded, so that it may be the more easily cleaned.

Some iron mangers are finished inside with porcelain enamel. This is not necessary if the iron has a smooth finish. Enamel

frequently cracks off, chips of which, if eaten with the food, are liable to provide a nucleus for the formation of a calculus. A slot in the front part of the manger-plate, through which the head-rope can play, is a more convenient and safer method than that of having a ring or hole in the front of the manger, with the rope exposed.

Hay Racks.—At one time hay racks were invariably placed above the manger at a considerably higher level than the horse's head, and though still sometimes found in farm stables and in the older type of commercial stables where renovation is prevented owing to expense, that position has been rightly discontinued for the more natural and safer position of a lower level. Overhead racks were, and still are, the frequent cause of eye injuries, through seed dropping into the eye when the horse stretches his head up to pull the hay out. With overhead lofts the high rack no doubt saves some

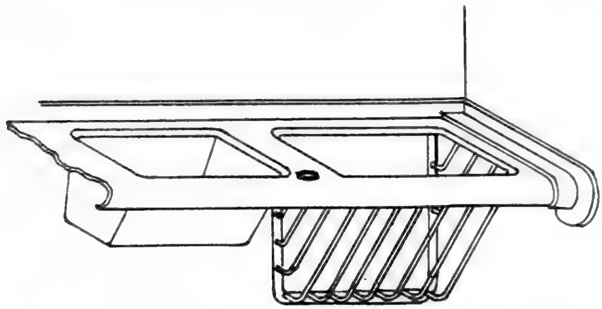


Fig. 65.—Cast-iron manger and hay rack. This type of rack is not recommended as hay is easily pulled out and drops to the ground.

labour when long hay is pushed down a trap-door immediately above them. The proper place for a hay rack is on a level with the manger. The low rack with the wide open top, as shown in figure 65, has an obvious disadvantage, as large bunches of hay are pulled out and dropped on the ground. To obviate this some racks are fitted with a sliding grid, which falls with the hay; thus the hay is kept in its place, but always within reach of the horse. A compromise between the low and high rack is seen in figure 67. This is a good type, being safe and not wasteful.

Mangers and hay racks for loose-boxes are more conveniently made as separate fittings and of a triangular shape in order to fit in the corners.

Water Pots.—It is a much disputed point whether horses should have a constant supply of water in front of them or not.

There can, however, be no question but that theoretically the hygienic ideal demands a supply of fresh water always available for the stalled horse. Unfortunately, a manger water pot very soon

becomes foul with the grain and fodder which the horse drops into it during feeding and drinking. The manger and food also get wet by splashing or by reason of the water conveyed to it by

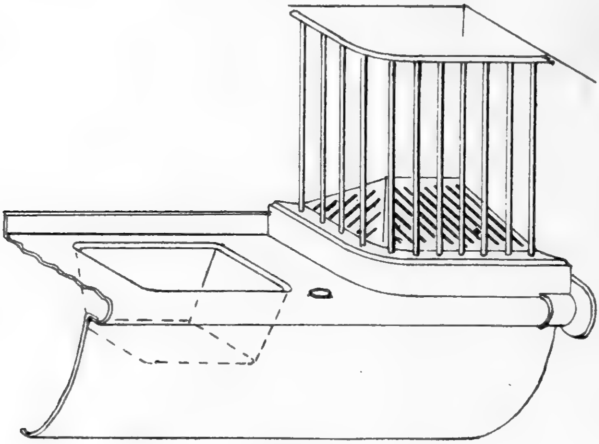


FIG. 66.

the horse after drinking. If a water pot of any design forms a part of the manger fittings, it is absolutely necessary that the pot, if not the entire manger, be cleaned out daily. Failure to attend

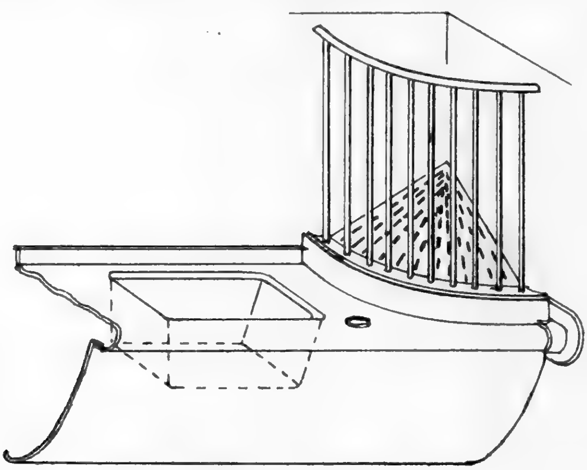


FIG. 67.

Figures 66 and 67 show two good types of manger and hay rack fittings, of which figure 67 is preferable owing to the better shape of rack.

to this results in a condition the reverse of hygienic.

It is not to be expected that in commercial stables there will be either time or labour to carry out this essential work, and in this class of stables the manger water pot is undoubtedly more of a nuisance than a benefit. For this reason, and for this reason only,

a constant supply of water in front of the horses is not recommended for stables, other than " private " stables. In private stables, where labour is not a consideration, the water pot is desirable.

The water receptacle may be a circular trough adjoining the grain trough. If provided with an outlet pipe and plug the pipe diameter should not be less than 2 inches, in order to reduce the risk of chokage. It should discharge outside the stable, and not be connected directly to the drain. Some water pots instead of being fitted with a plug are made in the style of a tip-up basin. The tap for filling the pot must be set in the wall out of the way, so that the horse cannot rub his head against it and get caught by the halter. Automatic fillers are not always so successful as the makers suggest.

The most hygienic, and the most easily cleaned, water-fitting is a ring which holds a bucket; the bucket can be removed and cleaned outside the stable, and, if water is not laid on to each stall, is readily filled at any tap. There are on the market bucket-holders formed of a ring of iron which, being hinged near their attachment to the wall and provided with a counterpoise, swing up when the bucket is removed, and fit into a recess in the wall. These are particularly suitable for loose-boxes. The objections to the use of permanent water pots in stalls do not hold good with loose-boxes, because here the water receptacle can be placed altogether away from the manger, so that neither get so foul as in a stall where space is more limited. As loose-boxes are in many cases used for sick animals rather than for regular working horses, a constant supply of fresh water is therefore an absolute necessity in them.

Yard-Troughs.—Advocates of the individual water-pot system plead that when horses are watered in the yard at a common trough, not only is the system of watering irrational, but that they are more likely to contract disease from one another. To a certain extent this may be true, but it is a recognised rule of stable management that if an infectious disease, such as influenza, makes its appearance in a stable or in a town, common water-troughs should be closed temporarily and each horse supplied from its own bucket.

A yard-trough should be placed out of the way of dust traps, such as are naturally formed at the end of a yard opposite the entrance gate. It is a mistake to have troughs too large. Within reason, the smaller the better, because they are the more frequently emptied and refilled with fresh water. In any case the trough should be emptied once daily, and once a week should be well scoured out. A suitable height from the ground is 3 feet.

Most yard-troughs are provided with a ball-cock, so that they

are self-regulating. The objections to the ball-cock trough are that it is less likely to receive attention than the ordinary trough, and that the ball-cock being covered over, the part under the covering is not easily cleaned.

Although a yard-trough is perhaps not theoretically the best, it possesses advantages, inasmuch as one trough is more likely to be thoroughly cleaned than are a number of stable pots. It is also

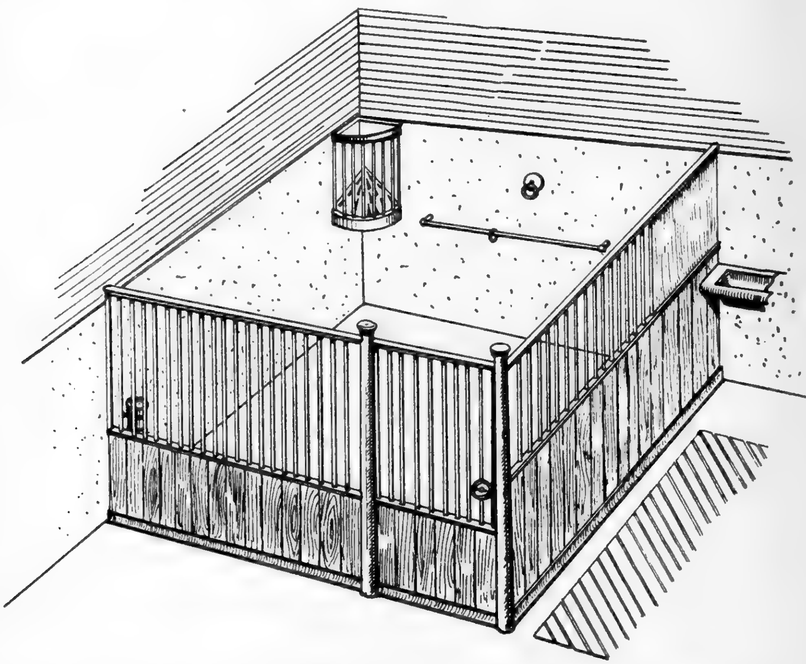


Fig. 68.—View of an inside loose-box showing fittings. The manger is in the corner opposite the hay rack. The side next the stall may be close-boarded throughout if desired.

more open to inspection, and in the light. It provides greater certainty that horses will get a sufficiency of water.

Loose-Boxes.—Whatever the size of the stud may be, at least one loose-box is necessary, and the urgent need for one is only noticed when it is wanting. If at all possible, loose-boxes should be built outside the stable proper, and removed some little distance from it, and should be out of the track of horses passing to and from their work. If economy of space and of money is not of pressing importance, one or more boxes can with advantage be included in the ordinary stable fittings in addition to one or more outside, but where it is not possible to have both inside and outside boxes, preference should always be given to the outside ones, and these considered chiefly for the use of sick animals.

Internal Loose-Boxes. — Boxes fitted in the stable naturally occupy the corners. The dimensions must be sufficient to allow of a moderate amount of freedom of movement, and for all ordinary purposes 150 square feet or so will be found to be ample if formed in a square. Seven feet is a suitable height for loose-box partitions, and this allows a good margin of safety. Wood panels surmounted by open rails are preferable to all-wood partitions as a better air exchange is possible, and animals can be seen without opening the door and thereby disturbing them. The close wooden parts of the partition separating the box from the adjacent stall should be about 4 feet in height; those of the door and passage partition need not be higher than 3 feet. The railings at the head of the stall must be filled in with iron sheeting as recommended for stall fittings. The door of the box must have a minimum width of 4 feet, as narrow doorways are a common cause of accidents. Doors must be hung to open outwards. If hung the reverse way, each time a door is opened the straw gets pushed in and caught under the door, or, if a horse is cast in the box and lying across the doorway, it is impossible to open it. The door fastening should be of the safety type, with the latch sliding out of sight and out of danger when the door is opened. It must be capable of opening from either side, and have handles flush with the wood. A manger, hay rack and water receptacle are best placed one in each corner.

It is sometimes recommended that loose-box walls be lined with wood to a height of 4 or 5 feet. This is not necessary, and indeed for sick boxes the practice is to be condemned owing to the increased difficulty in cleaning and disinfecting. Cement plaster is to be recommended for this purpose.

Convenience for fastening a horse in the box is necessary, for which a horizontal bar running between the manger and hay rack and on a level with them is as good a method as any. The bar should hold a ring to which the horse is tied, allowing him to move from manger to rack as he may desire. One or two rings, fixed about 5 feet 6 inches high, are convenient to tie the animal to when grooming.

The surface channel or gutter may pass under the door, or through any part of the partition which is most convenient, to join the main channel. The floor should be of concrete or metallic brick, grooved on the surface and falling away from the walls and partitions towards the channel.

External Loose-Boxes.—External boxes may form an integral part of the stable accommodation as in private hunting establishments, or be built solely for emergency purposes as for the reception

and isolation of the sick. In all cases one or more boxes should be isolated.

In general, the structure of an outside box is the same as that of an inside one. Woodwork should be dispensed with as much as is possible, and the walls lined with smooth-finished cement to a height of at least 7 feet from the floor. Above this the bricks or stones must be well pointed and washed over with cement, but need not necessarily have such a highly finished surface as the lower part, unless means permit of the cement being taken to the height of the ceiling. Bearing in mind that outside boxes are to be considered primarily as hospital accommodation, special care must be taken to ensure the easy and efficient cleaning and disinfection of them—hence the substitution of smooth cement for wood lining. For the same reason all internal corners and angles should be filled in to a 2-inch radius with cement. Manger and other necessary fittings must be of the simplest character, and in at least one box these fittings should be removable for the safer reception of colic cases. Doorways should measure 8 feet by 4 feet, and the door made in two portions, divided horizontally, the upper 3 feet 6 inches and the lower 4 feet 6 inches in height, each part opening back flush with the outside wall and fastening securely to it by a cabin hook. A steel angle screwed to the upper edge of the lower portion will prevent horses from damaging it with their teeth. Under ordinary circumstances the upper part of the door will be fastened back throughout the day, and probably also through the night, so as to give the inmate as much fresh air as possible. The majority of horses spend their idle time with their head over the lower door, taking full advantage of the fresh air and sunlight. As many horses develop the habit of pawing at the door, it is an economy to have the inside of the lower portion lined with sheet iron. The hinges of doors on outside loose-boxes must be carefully made, of the crook and band type, with the bands extending at least half the width of the door, and the crooks well tailed into the wall. Cheap iron-mongery and door fittings are always a failure, and in the long run have to be scrapped.

Each loose-box should have an overhead beam fitted with a lug-bracket from which a horse can be slung near the manger.

Horse Fastenings.—Horses must be fastened in their stalls in such a manner as will prevent them getting loose, or from stretching too far back so as to expose them to risk of injury from their neighbours. At the same time it must be possible for them to feed and to lie down and rest in comfort, without the risk of becoming entangled by the securing rope. This is effected by

having the head-rope just sufficiently long to enable the horse to lie down in the stall with his head resting on the ground. The rope should have a counterpoise weight attached to its free end, so that when the animal rises the rope shortens with his movements and does not hang in bights, being always in a sufficient state of tension to prevent its getting over the horse's head or under his legs. A one-pound weight is heavy enough for the purpose. The necessary length may be ascertained by allowing the horse to stand naturally in the stall well up to the manger, and letting the counterpoise just rest on the ground. Ropes, chains or leather straps, or two of these in combination, are variously used. Chains are economical in wear, but are noisy and are difficult to release in cases of emergency. Ropes are not noisy, and are quickly cut in the event of fire or a horse getting hung up during the night.

In some stables the free end of the rope passes through a ring attached to the front of the manger at its centre, and hangs directly under the manger, being kept taut by its counterpoise. As horses, especially idle or lightly worked ones, frequently acquire the habit of picking up the rope with their teeth and tossing the weight into the manger, or getting it twisted round the rope, it is an advantage to have both weight and rope enclosed under the manger with the rope running through a slot in the manger-plate. In order to keep all weight off the horse's head when feeding or standing up in its stall, a stop ring placed on the rope about a foot from the head-collar is useful. Noiseless-running head-ropes are supplied by some firms, and are excellent.

Harness Room.—Every stable, however small, should be provided with a room in which to keep harness, clothing and grooming kit. It should be used for no other purpose, and on no account should harness be hung in the stable. The size of the harness room will naturally depend upon the number of horses for which the stable is designed. It must be dry and well ventilated. The walls require to be boarded all round with match-boarding so as to protect the harness as it hangs against the wall. Artificial heat, such as a fire, stove or radiator, is necessary so that the harness may be dried and kept from rotting when put away from every-day use. For commercial stables lockers placed round the wall are almost indispensable. A locker should be allocated to each horseman so that he can keep in it his own grooming tools, &c. When closed, the lockers serve as seats on which the men can sit when polishing up their harness. The harness can be hung above the lockers on a saddle-bracket, bridle-bracket and collar-hook. A suitable height for the saddle-bracket is 5 feet, and for the collar-hook 7 feet above the

lockers. The saddle-brackets should be about 3 feet from each other and the collar-hooks placed midway between them. Suitable dimensions for lockers are 2 feet high by 1 foot 6 inches in width. A dry cupboard is necessary for the storing of rugs, bandages, &c., which should be carefully dried and aired before being put away. A cupboard, which like the clothing-store should be locked, is useful for storing medicine and first-aid dressings.

Food Store and Food Preparation Room.—In small stables a special food preparation room is not absolutely necessary, the hay and the straw can be chaffed in the loft over the harness room, into which the chaff and grain can be run by chutes. For a large stud a special food store and preparation room is very desirable. For general convenience it should be placed on the same level as the stable and communicating above with a hay loft. The preparation room must be light, dry, airy and rat-proof. The equipment necessary for the preparation and mixing of the food for a large stud of horses includes a chaff-cutting machine, which may be fitted with winnowers and sifters, but the so-called deleterious effect of the dust in hay and straw has been greatly overestimated. It is, however, necessary to see that nails, cut wire, &c., are removed from the chaff. A combined oat-bruiser and bean-kibbler should be installed in every large establishment.

Artificial Light.—Some form of artificial lighting is necessary in every stable. Electric light should, of course, be used if it is available, and the cost of installation is not too great. Of gas, incandescent should always be used in preference to ordinary gas as it gives a better light and its combustion products are considerably less. Whatever light is used, whether oil lamps or either of the foregoing, the fittings must be hung sufficiently high to be out of reach of the horses.

COW - SHEDS.

Types of Byres and General Arrangement.—The planning of a cow-shed must be carefully considered, as attention to detail of structure and fitting has a great effect on the health of the animals, the quality of the milk, the comfort of the attendants, economy in labour, cost of initial construction and of subsequent upkeep.

It must be clearly understood that it is unnecessary to incur great expenditure in order to build a hygienic byre, and that it is usually possible to reconstruct an insanitary building without great or unreasonable expense. Fancy fittings and costly and complicated ventilating systems are not only unnecessary, but undesirable.

The cow-shed should be as simple as possible. The most important points to study are:—Suitability of site; sufficient cubic space to allow of air change without "draught"; a proper proportion between floor space and total cubic space; efficient ventilat-

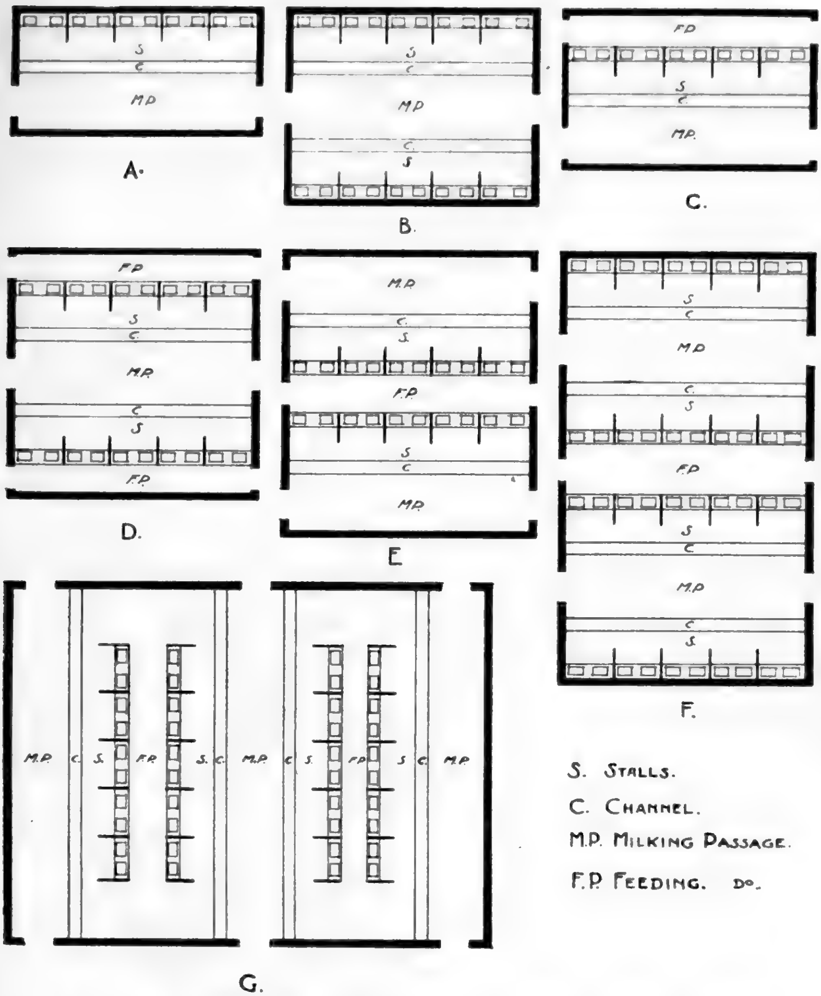


Fig. 69.—Different plans for cow-sheds, some of which are bad.

ing and lighting; the general arrangement of the cows in the building; details concerning the stalls and feeding appliances and construction of the building so that cleansing is easily carried out, and that the labour of tending the animals is reduced to the necessary minimum.

There are various ways of planning the internal arrangement of a cow-shed. The diagrams show the more common methods, some of which are bad.

In *A* and its double counterpart *B* the cows stand close to the wall against which are placed the food-troughs. In *C* and *D* a feeding passage or alleyway is interposed between the cows' heads and the facing wall. In *E*, a double byre, the cows stand facing the centre of the house with a feeding passage between them, a milking and cleaning passage being behind. A byre of the type *F* is designed to hold four rows of cows under one roof and is a combination of *D* and *E*. In *G* the animals are arranged in transverse rows across the building.

Types *A, B, C* and *D* have no objectionable features and all of them are in common use. *E, F* and *G* are all bad plans and should not be adopted. Animals should never be placed so that they stand facing each other as there is more risk of infectious disease being

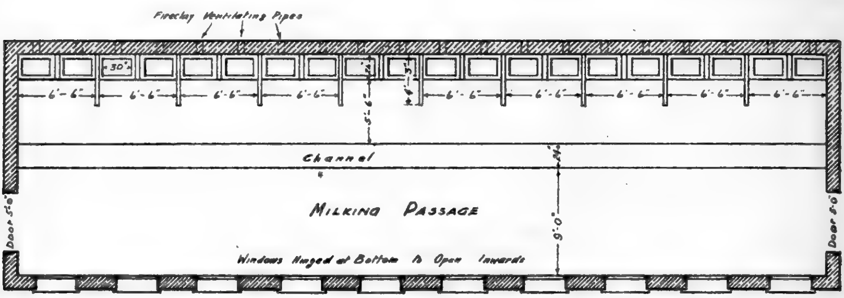


FIG. 70.—Plan of a single cow-shed without a feeding passage.

spread from one to the other, and also because satisfactory ventilation of such a building is difficult. Animals should stand facing the air inlets so as to get the maximum benefit of the fresh incoming air. It is very often the case that a central feeding passage is turned into a temporary store for roots and similar food instead of being put to its legitimate use. Instances have been known where such a passage has been used as a pen for calves—a very bad practice as it exposes the young animals to an extraordinary risk of tubercular infection. *F* and *G* are particularly bad arrangements as with either it is practically impossible to provide the animals with a proper supply of fresh air.

Some difference of opinion exists concerning the advisability of having a feeding passage in front of the cows as shown in *C* and *D* or whether it is better to dispense with the passage and stand the cows close to the facing wall. For the system it may be said that there *may* be some saving of labour in feeding when the byre is a big one and holds a considerable number of cows. Feeding passages undoubtedly add to the cost of construction, increase the labour of cleaning the byre, and materially increase the difficulty

of keeping the standings clear of fæces and urine because, with a clear space in front of them, the cows have more forward movement than is the case when they are tied close to the wall. At feeding time the animals press forward in their eagerness for food, and in so doing move away from the dung channel behind them with the consequence that excreta is dropped on to the standing instead of into the drain, and cows almost invariably void their excreta when they rise to their feet. This is a very important objection

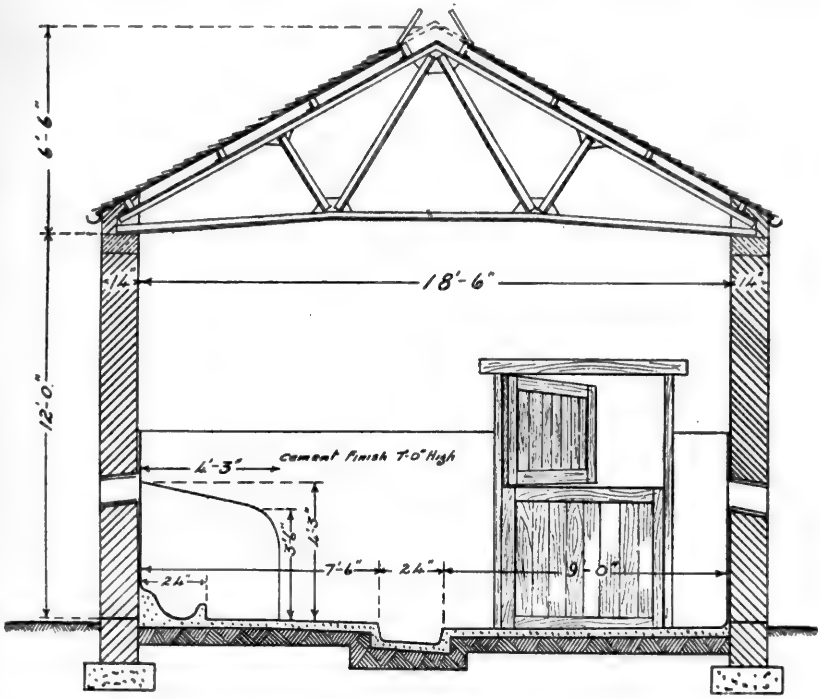


FIG. 71.—Section of a single byre without a feeding passage. It is fitted with Findlay's air outlet system and direct fireclay air inlets. The dimensions given are suitable for large cows.

to the use of feeding passages. Attempts to prevent the animals moving forward by placing bars or similar obstacles in front of them are not always successful. It is questionable if any economy in labour is really effected by the use of these passages because what is gained in one way is lost in another. On the whole, dairymen do not regard feeding passages with favour. Should, however, a feeding passage be desired it must have a *minimum* width of 4 feet. The flooring must be of impervious material such as cement concrete and be laid so that it can be easily cleaned.

Stalls.—The actual area on which a cow should stand and lie, that is the size of the stall, is necessarily limited so as to prevent

her dropping fæces and urine on the floor in such a position that she would lie on the excreta and thereby soil her quarters and udder. It is true that this limitation of space greatly restricts the animal's movements, but it is absolutely necessary for the production of clean milk.

If the stall is too big in either breadth or length it becomes covered with dung owing to the animal moving about. If the stall is properly constructed, the excreta should fall into the dung channel at

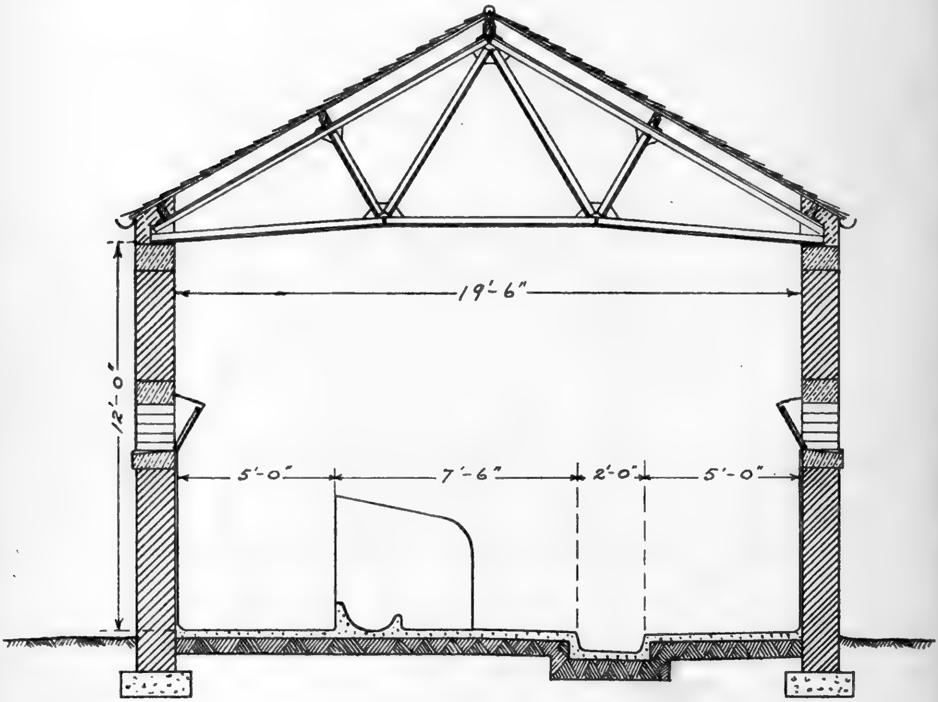


FIG. 72.—Section of a single byre with a feeding passage, Sherringham windows and steel roof trusses. Outlets for foul air may be by extraction cowls or louvred ventilators. The dimensions given are for large cows. The feeding passage may be one foot less and the milking passage one foot wider if desired.

the rear. If the stalls are so constructed that cows are perpetually soiling their udders with manure, the labour involved in keeping them clean is so great that it is seldom satisfactorily done. In the majority of cases the most that is attempted under these conditions is to remove the more obvious cakes of dried dung and dirt with the result that what remains on the cows' flanks and udders is loosened and falls into the milk pail at milking time. Attendants soon get disgusted with trying to keep cows clean under such conditions, but where the stalls are properly designed little dirt gets on to the animals and they have some encouragement in their work. It has for long

been recognised by architects who are conversant with veterinary hygienic requirements that stalls must be designed to fit the cows the byre is likely to house.

The length of a stall should be such that when the cow is standing in a natural manner the heels of her hind legs are just at the border of the channel at the rear of the standing. It is plain that as the length of cows varies, so must the length of the stalls, for a stall that would suit one cow may not suit another. For the small breed of cows, such as Jerseys and Kerrys, Spier* recommended a length of 6 feet 10 inches to 7 feet from the facing wall to the gutter edge; for medium size cows, such as Ayrshires, 7 feet to 7 feet 3 inches; and for Shorthorns a length of 7 feet 6 inches. An occasional cow may be found for which this outside measurement is insufficient.

In all dairy byres, and especially in commercial dairies where breeding of one type is not the custom, there will be cows of all sizes so that it is advisable to grade the length of the stalls down the byre. This is done by making the stall at one end of the byre 9 inches longer than the one at the opposite end. This plan is now in common use in first-class cow houses of modern construction, and meets with unqualified approval. In byres where one type of cow is kept, such as pedigree stock, it is unnecessary to have the extreme range of gradation. Local circumstances will decide this point. A method sometimes adopted is to make the stalls on one side of the byre a little shorter than those on the other side.

The common custom is to keep cows in pairs in double stalls. This effects a saving of labour in milking and tending the animals, and reduces the cost of construction. The breadth of the stalls is an important consideration. If they are too broad cows can turn sideways and foul the standing with fæces, and if they are too narrow the cows, in double stalls, tread on each other's legs and udders. Many cases of mammitis are caused by injuries from treads. Apart from any direct injury to which they are liable, cows placed in stalls too narrow are in great discomfort owing to the difficulty they have of lying down at the same time.

The width for double stalls should be from 6 feet to 6 feet 6 inches for small animals and from 6 feet 6 inches to 7 feet 6 inches for the larger animals. For single stalls an inside width of 4 feet will be found suitable for most cattle.

Should the stalls be too short the cows stand with their hind feet perpetually in the fæces channel, to the marked detriment of the

* Journal of Board of Agriculture and Fisheries, Oct., 1909.

hoofs and fetlocks, and to the obvious discomfort of the beasts both when standing or lying.

Slope of Stalls.—The floor of a stall should be practically level from front to back, with the exception of the rear 3 feet which should slope toward the channel behind so as to carry off urine and water. A drop of $\frac{1}{2}$ in. in the 3 feet is ample. If there is no gradient at all, the rear part of the stall is sure to be constantly wet.

Flooring of the Stall.—The most suitable material for the flooring of stalls is cement concrete. Some dairymen prefer to have the front 3 feet, from the manger backwards, formed of softer material such as common building bricks, asphalt, clay or chalk rubble—the idea being that cows develop enlarged knees, or hygromas, from constant contact with cement. It is true that a few cows are found so affected but it is not common, and dairy cows do well enough when the whole flooring is of cement. Any porous material in this position would necessarily reduce the hygienic efficiency and make the stall less easily cleaned.

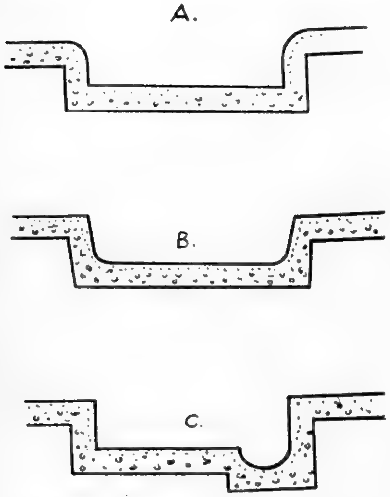


FIG. 73.—Three types of drain channel for cow-sheds.

A is a bad type as cows slip on the rounded edge.

B shows a good type of channel that is simple and efficient.

C shows a separate channel for urine; it is not a good method.

Drainage of the Byre.—The construction of the drain channel at the rear of the stall is of great importance owing to its close bearing on the cleanliness of the cows and, consequently, the cleanliness of the milk. It must be clearly understood that no form of underground drainage is permissible in any cow house. The drain must be an open channel running the length of the byre behind the stalls. The importance of the relation between the length of the stall and the drain has already been made plain. The channel must be wide enough to hold dung and such bedding as may get into it without becoming overloaded and blocked between the usual periods of cleaning it out. This is usually done twice daily, in the morning and again in the evening before the cows are finished off for the night. Two feet is the minimum breadth that should be allowed if the channel is to be satisfactory, and it may with advantage be increased. The average depth should be 5 or 6 inches at

the side next the stall and, in order to keep the urine as far from the stall as possible, the bottom of the channel must be made with a backward slope of 1 inch, as shown in figure 73.

It is a common practice to construct the stalls so that they are a few inches above the level of the passage behind. The drain channel is sometimes made as shown in figure 73C, the idea being that the second drop carries away the urine more expeditiously than if the drain is constructed as illustrated in figure 73B. This second channel is unnecessary, it adds to the cost of construction, increases the labour of cleaning the drain and has little or no advantage over the more simple type. The corners at the bottom of the channel should be rounded and the whole surface made as smooth as possible.

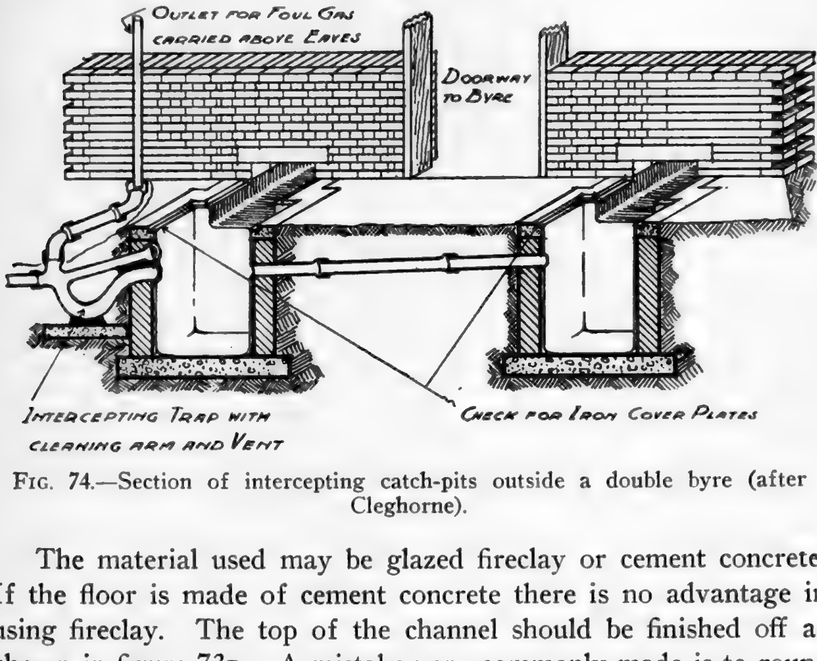


FIG. 74.—Section of intercepting catch-pits outside a double byre (after Cleghorne).

The material used may be glazed fireclay or cement concrete. If the floor is made of cement concrete there is no advantage in using fireclay. The top of the channel should be finished off as shown in figure 73B. A mistake very commonly made is to round off the upper angle as shown in figure 73A. Cows are much more liable to slip on the latter formation than on the former. The gradient of the channel must be sufficient to carry away the urine, and if the building is a long one then it is advisable to slope the whole of the floor to a gradient of about $\frac{1}{2}$ in. per cow, not more, and to make up the remainder of the necessary fall by giving a drop to the channel. If the whole of the fall were to be obtained by sloping the channel, the floor being level, it would have an undesirable depth at its outlet end. In short cow houses there is, of course, no need to give any slope to the floor. If the byre is very long it may be necessary to slope both ends of the channel toward the centre

of the building, from which point a cross drain will carry the urine out of the building. Unless really necessary, which rarely will be found to be the case, the drain should run without interruption from one end of the byre to the other.

Milking Passage.—The milking and cleaning passage behind the cows must be of ample width for several reasons. If the cubic air-space is to approach what we consider to be the minimum allowance, and that without having an inordinately high building, the passage for a single byre must be 9 feet wide. This width with stalls 7 feet 6 inches long and a dung channel 2 feet wide will give an inside width to the building of 18 feet 6 inches. It is at once admitted that this width is in excess of that usually provided, but unless the air-space is to be less than what is required a narrower passage will not serve. A wide passage gives more freedom to cows entering and leaving the byre and it prevents the splashing of the wall with dung and urine which is so common and so unsightly in narrow buildings. The passage must be laid with a fall of 1 inch from the wall to the channel.

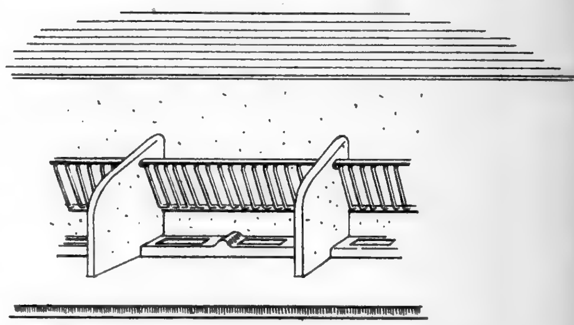


Fig. 75.—View of a double cow-stall fitted with individual food-troughs and a continuous hay rack. The stall partitions are of cement concrete.

Air-Space.—If the height of the walls is 12 feet and the roof height 6 feet from eaves to ridge, the gross cubic air-space of a single byre having the above dimensions will be 970 cubic feet. From this must be deducted 20 cubic feet for the space occupied by each cow, so that the net cubic air-space per animal will be approximately 950 cubic feet. Though a net air-space of 950 cubic feet is really less than what is desirable for large cows it is probably as much as can be expected owing to the high cost of building.

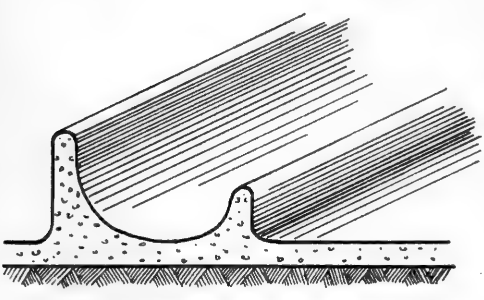


Fig. 76.—Cement concrete continuous food-trough for cows.

The *Floor-Space* of such a byre is 65 square feet per animal,

or one-fifteenth of the total number of cubic feet of air-space.

Food-Troughs.—There are many opinions as to the most suitable fittings for the feeding of dairy cows. The food-troughs used range from the simple concrete or glazed fireclay trough without separate divisions for each cow, or pair of cows, to individual troughs fitted with a water pot at the side and a hay rack above. The single trough possesses one great advantage over divided ones inasmuch as it is very easily cleaned by flushing it out with water from one end to the other without the expenditure of much labour, an important consideration in a dairy byre. The disadvantages of the single trough are, however, very marked. It is difficult, in fact almost impossible, to see that each cow gets her proper share of food, and this, where feeding is done according to milk yield, is of some importance. To some extent this difficulty may be overcome by placing one or two iron rods across the manger between each cow. With undivided troughs cows are inclined to eat their food too rapidly, and on this account individual troughs are to be preferred to a continuous single one. On the other hand, cows' troughs soon become very dirty, especially when sloppy fermentable food or wet brewers' grains are used, they therefore require to be cleaned frequently. This is a laborious and difficult matter with divided troughs and is seldom effectually done. Whatever type of trough is used it should be placed on the ground level, or even with the bottom of it a little below the ground. The depth should not be greater than 8 to 10 inches, and, with advantage, the side next the cows may be as low as 5 or 6 inches. The reason for having the front of the manger low is that if it be high the cow cannot lie down without stretching back the full length of the chain to get her head clear of the obstacle. The length of the stall would then have to be greater, in fact measured from the manger instead of from the wall. With such an arrangement the cow on rising would step forward in order to get her head over the manger to feed and would in consequence drop her fæces on the standing instead of into the channel. When she wishes to lie down again she would perforce step back and consequently lie down on her droppings. With a manger low in front the animal can lie down where she stood when feeding and with her head resting comfortably over the manger. The breadth of the manger need not be greater than 18 inches and, if each cow has her own portion divided off, 20 inches in length is sufficient. With double stalls the space between the troughs should be filled in as shown in the figure.

If there is no feeding passage in front of the cows the troughs

ought not to be placed close against the wall but set from it a few inches and the space filled in with cement sloping up the wall. This little extra space allows cows to rise with greater ease and is necessary for large horned cattle. All angles formed at the junction of the trough with the wall, partition, and floor must be filled in with cement so as to facilitate cleansing. Troughs may be of glazed fireclay, cement or iron.

If hay racks are desired they should be placed above the mangers on a level with the cows' heads when they are standing. Figure 75 shows a suitable rack for a byre without a feeding passage. Hay racks are not commonly used in commercial byres, the hay or straw being usually put down in front of the cows when they have finished their concentrated food and milking is over. In some localities, however, their use is more general.

Watering.—Cows are either turned out from the byre into a yard to drink from a common watering trough, or in some cases a pond, or they are supplied with water in the byre. In the latter case they may be watered by hand with a bucket or there may be some form of common supply, or each cow or pair of cows may be provided with a separate water pot. The only advantage which cows gain by being turned out to drink is that they get a certain amount of exercise during the winter months, but they are seldom let out often enough and, consequently, are inclined to drink to excess at the time. Insufficient water and prolonged periods of abstinence are most common causes of digestive troubles and impaction of the rumen and omasum. The practice of turning cows out of a warm, often too warm, byre into the cold wintry air to stand and drink large quantities of ice cold water is not to be recommended. Outside watering for cows cannot be considered in the same way as for horses, because the latter pass in and out of their stables more often than do cows and they are not kept confined in a warm building throughout the day. Milch cows require a plentiful supply of fresh, wholesome water, and they should have access to it at all times. Hand watering with a bucket is unsatisfactory and is not to be recommended; such a method is too extravagant with labour and time, and is too much dependent upon the human factor to be a success. Cows should have a supply of water constantly before them. This may be arranged either by having a continuous trough fixed to the wall or by giving each cow, or pair of cows, a separate trough. Individual pots are sometimes fitted with a lid that the animals soon learn to lift with their noses when they want to drink. Some water pots are self-filling so that there is a constant level of water. One continuous trough

is more simple than a number of separate pots and is easily cleaned by opening a valve at one end.

Stall Divisions.—Stall divisions are for the purpose of preventing cows from lying across the stalls. They are made of brick, brick faced with cement, cement concrete, cast-iron or tubular iron. The partitions should not be too large, 4 feet 3 inches long and 4 feet 3 inches high are suitable dimensions, or they may fall away to 3 feet 6 inches at the rear. If partitions are too long and too high, cows have difficulty in entering and leaving the stalls. Simple tubular iron divisions are quite satisfactory if they are carried far enough back to keep the cows in their proper places. If solid partitions are used they should be of cement concrete finished with a smooth, hard surface so that they can be easily cleaned. Cast-iron is also suitable. Wood should not be used if it can be avoided.

Lighting and Ventilation.—Not less than 3 square feet of glass must be allowed per cow, and the lighting should be so arranged as to light up the hindquarters of the animals. Findlay's overhead system is undoubtedly the best (see Ventilation), and this may be supplemented, if necessary, by wall windows. Ventilation has been discussed in a former section. The most efficient method is that where there is an open ridge. The inlets should be simple, and an ordinary fireclay pipe let in the wall just above the food-trough gives excellent results (see Ventilation).

The *Walls* must be finished with a smooth, hard surface or be faced with glazed tiles or bricks to a height of 7 feet; above this they should be smooth finished to prevent lodgment of dirt and dust. All corners and angles in the byre must be filled in with a fillet of cement. There must be an ample water supply in the byre for cleansing purposes. The *Flooring* must be impervious, hard and free from pits and inequalities; cement concrete is the most suitable material.

The *Doorways* must not be less than 5 feet wide and 7 feet high. There should be one at each end of the byre. They may be of the sliding type, running on rollers and placed outside the byre or made like loose-box doors in two parts so that in close weather the upper part may be left open.

Food and Manure Carriers.—In large byres a great saving of labour is gained by using carriers for the soiled litter and dung and the food. These may run on tracks or on overhead wires, one set going direct to the dung pit and the other to the food preparation house.

Securing Cows.—For reasons already given cows have to be confined to a definite and circumscribed area. It is therefore neces-

sary that they should be so tied or fixed as to limit their movement. The most common practice is to tie them round the neck by means of a chain or rope, the other end of which is secured to a ring that has perpendicular play up and down a rod bolted to the partition. The perpendicular play must be sufficient to allow the animals to rise and lie down with ease. The length of the chain must be such as will not permit of any appreciable backward or forward movement. The rod should be 1 foot 6 inches in length, and the lower end of it should be 1 foot from the ground. It should be placed about 2 feet 6 inches from the wall. Chains are more durable than rope and they are quickly adjusted and released if there is no strain on them. In the case of acute illness, such as milk fever, it is often a matter of great difficulty to release a recumbent and unconscious cow. If properly tied, ropes can be quickly released or at the worst can be cut. Patent quick releasing fastenings are put on the market by manufacturers. Broad leather straps are sometimes fitted to the chain, they are easier on the cows' necks than chain but are not so popular with dairymen. A method of fixing cows in their stalls and preventing too much movement that is being largely adopted is the use of a kind of pillory or yoke that is hinged at the bottom and opens at the top. Both top and bottom are attached to a few links of chain, thus a certain amount of movement is possible.

Calf Houses.—Calf pens must be light, dry and airy but not draughty. Each calf should be allowed not less than 180 cubic feet of air-space. The lighting should be so arranged as to admit as much sunlight as possible. The floor, walls, partitions, &c., must be constructed so that cleansing can be easily done. If possible, an exercising ground should be close to, if not actually an annex of, the calves' house so that the young growing animals can get plenty of exercise and fresh air when weather conditions permit. Calf houses are commonly the worst constructed places on a farm, being frequently dark, damp, unventilated and undrained, and they are often kept in a very dirty condition.

Food Preparation Room.—A food preparation and mixing room should be attached to the cow house for convenience in mixing and preparing the food. Under no circumstances should food be stored in the byre.

Milking-Shed.—A separate milking-shed apart from the byre is a great help toward the production of clean milk. The idea of such a shed is that the cows are moved at milking time to a building that is free from dust. They are there tied up in the usual way, given a feed of concentrated non-dusty food and milked. The

animals should be groomed and have their udders cleaned in the general byre so that no dust is caused in the milking-shed. The floor of the shed should be washed down with water before the animals enter so as to keep down dust. The milking-shed should be free from all unnecessary fittings, be hygienically constructed and well lit and ventilated. It should not be placed in an exposed and dusty position.

Close to the milking-shed and connected to it by a passage (so as to avoid dust) should be placed the *Milk House*. This must be a cool, well-ventilated building, and the most careful attention must be paid to details that will ensure that the place can be kept clean and free from dust. The windows and all ventilating apertures must be screened to keep out flies. The fittings installed will depend upon the method of handling the milk, but in any case there should be facility for cooling the milk.

The Roof Truss of the cow-shed and milking-shed should be as simple as possible so as to lodge the minimum amount of dust (see section on Roofing).

PIGGERIES.

Pig houses range from the single pig-sty of the cottager to large piggeries capable of housing some hundreds of pigs such as are erected by those who make pig-keeping their business.

The single pig-sty usually consists of a small covered-in pen to which is attached a small open court or space a few feet square in which is placed the food-trough. Larger piggeries are often constructed on the same principle, that is to say, the pigs sleep in a small covered-in space and pass out into an open unroofed part to take their food. Other piggeries are entirely roofed, and may or may not have an exercising yard outside the building. The disadvantages of the partly closed and partly open piggery are very real. The animals lie huddled up in a space that is often too small and unventilated while they rest and sleep, and have perforce to pass out into the open air and often to stand in rain and snow to eat their food. They suffer from extremes of temperature, and their sleeping quarters as often as not are undrained and damp. Since the desired object of housing animals is to keep them in an equable temperature and to keep them dry, it is obvious that this method has nothing to recommend it, and it is not to be confused with the open-air system of pig-keeping which is an excellent method when properly carried out. The outer court, therefore, should always be roofed over, though it may be left open at one side to admit light

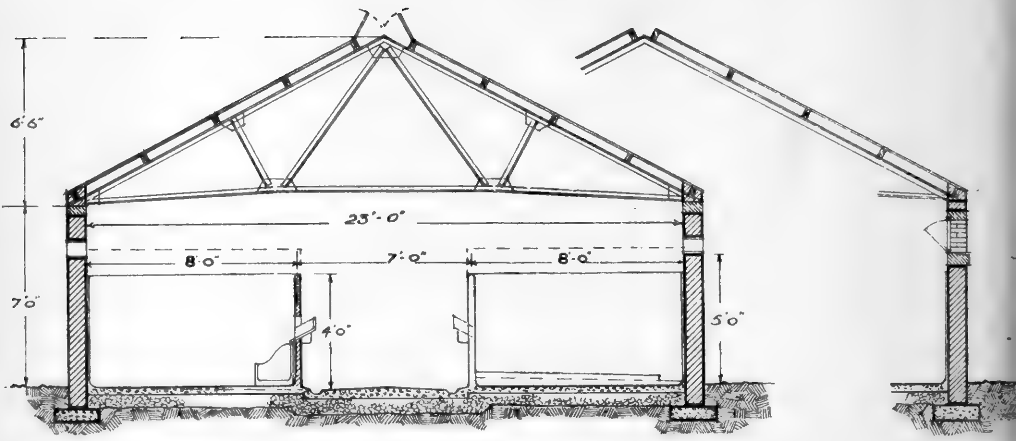


FIG. 77.—Section of a piggery. The dotted lines above the pen partitions indicate the height to which the partitions should be built for a boar's pen. An alternative method of providing outlet for the foul air is by a permanently open ridge as shown in the adjoined figure, in which case the Sherringham windows are used instead of fireclay pipes for the air inlet.

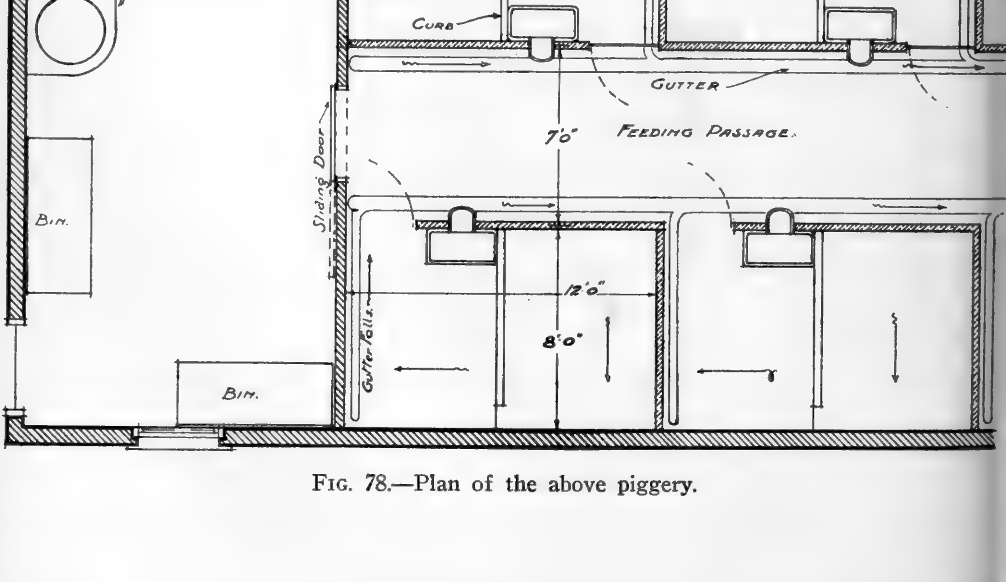


FIG. 78.—Plan of the above piggery.

and air. While the larger piggeries are mostly roofed in, some object to this method of housing on the ground that it tends to produce delicate stock. It is clear that such opponents to this system do not appreciate the fact that the housing of animals at all is to protect them from adverse weather conditions, and that it is as simple to erect a hygienic piggery as a hygienic stable for horses.

Large piggeries are sometimes arranged so that the buildings occupy three sides of a square, the fourth being open and facing the south; or in the form of one or more buildings with the pens arranged down each side with a passage running down the centre. This latter arrangement is more economical with labour and has no objectionable features. Its construction should be on the following lines :—

A pig, like all other animals, requires plenty of fresh air and, as it is susceptible to draughts, needs an air-space in the building sufficiently great to prevent a too frequent exchange of the air. If reference is made to the table given on page 90, it will be seen that the cubic space for a large fatting pig or a sow should not be less than 270 cubic feet, and may with advantage be considerably greater. Practical experience has shown that approximately 100 square feet is a suitable floor space for a sow with a litter of pigs, and that a pen of this size will comfortably hold three or four fatting pigs according to their size. The most convenient arrangement of space is to have the pens about 12 feet long and 8 feet wide, thus with a feeding passage 7 feet wide down the centre with pens on each side, the inside width of the building will be 23 feet. The walls need not be higher than 7 feet and the height of the roof with a span of 23 feet would be 6 feet 6 inches (if slate covered). With the floor space allotted as suggested this will give an air-space per fatting pig of 471 cubic feet if three pigs are kept in one pen or 353 cubic feet for four pigs.

If the pens are arranged with one dimension greater than the other, as described, instead of in the form of a square, one part can be conveniently marked off for sleeping quarters and the other part, which holds the food-trough, for feeding. With this arrangement it will usually be found that the pigs when they have grown to any size will not foul their sleeping quarters, but will pass to the other part to get rid of their excreta. The arrangement is shown in the plan. The floor of the sleeping quarters may be built two or three inches higher than the remainder of the space and should be surrounded by a low cement curb with the exception of a small space left for washing and urine drainage. The sleeping portion of the pen may or may not be fitted with a removable wooden platform,

but this is unnecessary, and many pig-breeders have shown that it is possible to rear healthy pigs on plain cement concrete. The floor should be laid with a gradient to carry off water so as to keep it dry.

The walls separating the individual pens require to be 4 feet high, with an additional foot for the boar's pen. If built of $4\frac{1}{2}$ inch thick brick in cement mortar they will be sufficiently strong.

The flooring of piggeries, as for other animal houses, must be of impervious material, and there is nothing better than cement concrete for both pens and passages. Many pig-keepers prefer ordinary building bricks for the floor of the pens as they are

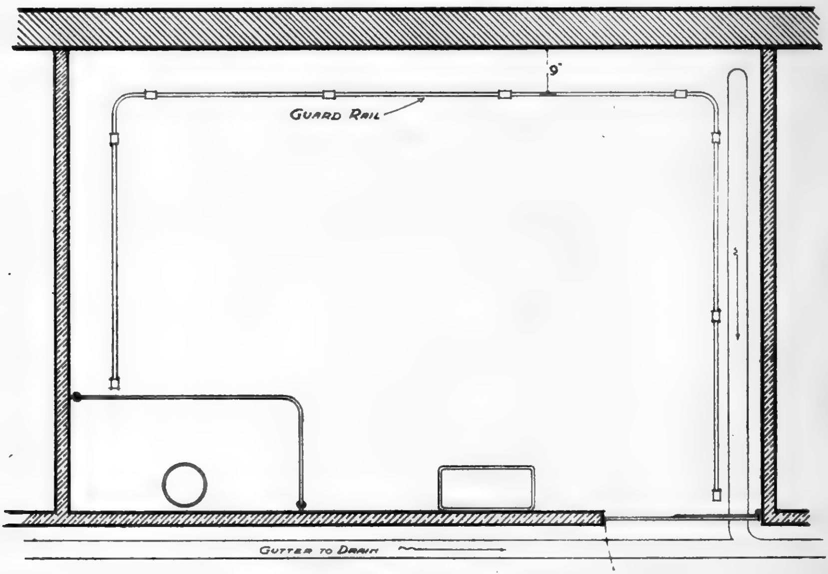


FIG. 79.—Plan of a farrowing pen showing the position of the guard rail, the food-trough and the weaning pen with food-trough for young pigs enclosed. The guard rail should have supporting ties to the walls.

warmer than cement. Bricks soon wear unevenly, and the binding material between them works loose. The bricks being very absorbent do not make a floor that is easily kept clean. The floor of the pens must be given a sufficient gradient to carry wash-water and urine into the channel which should be placed outside the pens as shown in the plan. In some piggeries the drain channel is outside the building at the rear of the pens, in which case the pens should, of course, slope towards it. The former method is the better, and the channel should run as an open drain until it has passed through the building and there discharge over a perforated iron plate into a drain connected with the liquid manure tank, if one is provided, or into the sewer. The passage in the centre of the building must be laid so as to drain into the channels at the side.

Lighting and Ventilation. — From the table giving the inlet and outlet area for the various animals, it will be seen that at least 23 square inches of inlet and a similar allowance for outlet are required for each large fatting pig or sow. In comparison with what is usually allowed, this, no doubt, will seem excessive, but there is no reason why there should be one law for bullocks and horses and another for pigs. Pigs thrive well if given plenty of fresh air, and young stock reared under these conditions are much hardier than those kept in close, confined quarters. Pigs are very susceptible to draughts, perhaps more so than any other animal, and for this reason the air inlets should be placed higher up than is necessary

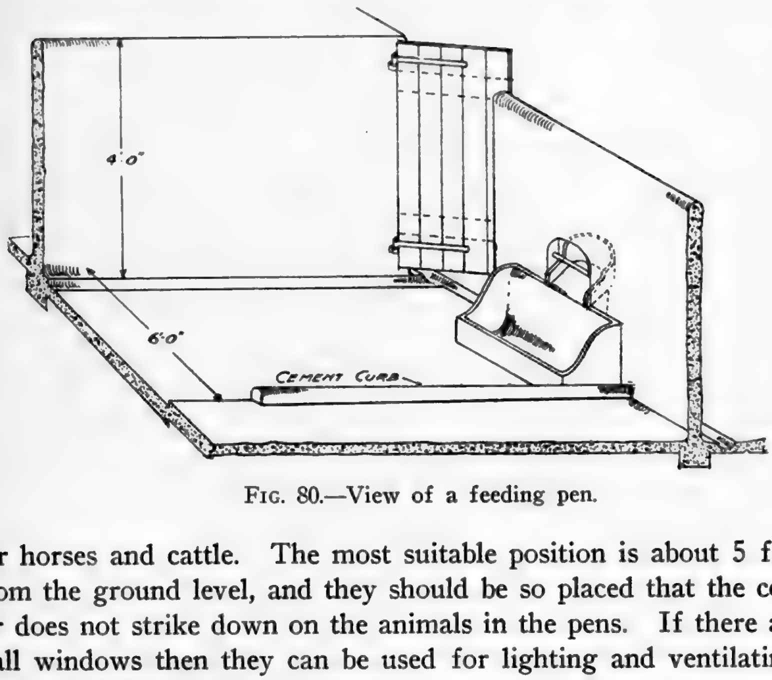


FIG. 80.—View of a feeding pen.

for horses and cattle. The most suitable position is about 5 feet from the ground level, and they should be so placed that the cold air does not strike down on the animals in the pens. If there are wall windows then they can be used for lighting and ventilating, the Sherringham valve or hopper type being the most suitable. If the lighting is all done from the roof, then drain pipes set in the walls are economical and efficient inlets, and they may if necessary be supplemented by air bricks. The outlet should be at the roof ridge as described in the section dealing with ventilation. Roof skylights are to be avoided over the pens, as when open they make them cold and draughty.

The walls of the buildings and the partition walls of the pens should be given a smooth, hard face with cement; the walls to a height of 4 or 5 feet and the partitions on all surfaces and top edges. All corners and angles must be filled in with a cement fillet.

If a boiler house is included in the general arrangement of the

piggery it should be placed at one end of the building and made continuous with it, but be separated from the piggery by a sliding door as shown in figure 78. The steam generator and coal store may be placed in one corner as shown, with the digesters along the wall. Each digester must be provided with a vent pipe to carry the waste steam out at the roof so that the atmosphere does not become surcharged with moisture. Bins for holding meal, &c., may be conveniently placed along the opposite wall. Stores for roots and green crops should be outside

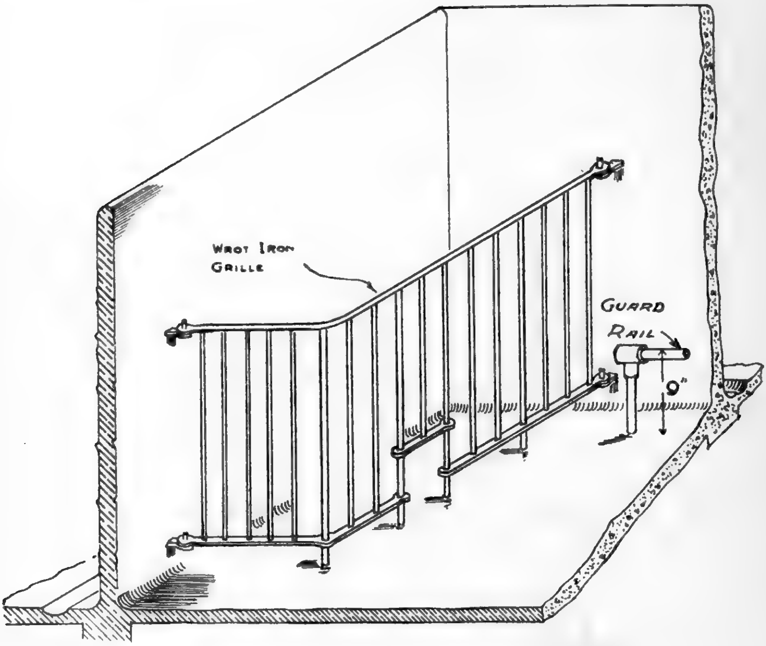


FIG. 81.—View of a weaning pen in a farrowing pen.

the building, but close to it for economy in labour. The dung pit should be at the opposite end of the building away from the food preparation room and food stores. Along the back of the pens there should be a fenced-in space into which the pigs may be turned daily for exercise. This is a matter of convenience when the pens are being cleaned out, and it is also good for the animals.

Fitting of Pens.—Breeding pens ought to be fitted with a guard rail round three sides of the pen as shown in the figure, the material most suitable for which is $1\frac{1}{2}$ inch galvanised malleable iron piping. It should be set 9 inches from the wall, and an equal distance from the ground. The object of this guard is to protect the little pigs when the sow lies down so that they are not crushed against the wall. This is an important fixture as without it many piglings get killed.

In the breeding pen it is advisable to have a small weaning pen in the position shown in the figure. Food for little pigs can be placed in this enclosure to which they can get access, but which the sow cannot reach.

The Food-Trough.—This should be placed on the side of the pen next to the passage as indicated in the plan. For convenience in feeding where a large number of pigs is kept, the trough should be so constructed that feeding can be done from the passage without having to enter the pens. This may be effected either by means of a chute, as shown in figure 77, or by having a swing shutter. There are several types of swing shutters on the market made of cast-iron. Though excellent in principle, they often cause a deal of trouble owing to the ease with which they get fractured and out of order; if made sufficiently strong and heavy they may be usefully employed. A feeding chute, however, is preferable to a swing shutter. It should be situated at a proper height to discharge cleanly into the trough, and the angle of deflection should be about 45 degrees. A suitable size is 12 inches by 7 inches. Flaps, lids and projections which are sometimes attached to the chutes are not necessary. The chutes may be of iron or of fireclay. The food-trough may be of fireclay, cast-iron or cement concrete. Cast-iron troughs are very liable to get fractured. Fireclay makes excellent troughs that are easily cleaned. Cement troughs are often built *in situ* with a hole left at the end next to the door and fitted with a plug which can be removed when the trough is washed out. Cement is a suitable material for food-troughs if it is finished smooth and given a hard face, but many local tradesmen fail to do this and leave the trough so rough that it is impossible to clean it out properly. Some troughs are fitted with a number of cross bars to prevent pigs, when feeding, from stepping into and urinating in them. Movable troughs must be given a wide base, otherwise

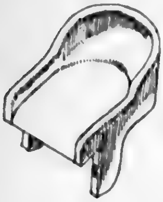


Fig. 82.—A food chute as shown in figure 80.

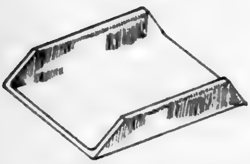


Fig. 83.—Another type of food chute.

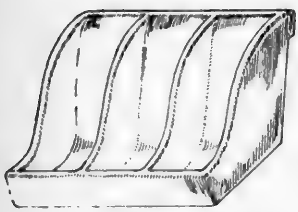


Fig. 84.—A pig's trough designed to prevent pigs fouling their food.

Fig. 85.—A shallow type of trough.

they will be overturned. If dry or semi-dry food is given to the animals then a water-trough must be provided so that they may get a sufficiency of fluid.

DAMPNESS IN BUILDINGS AND ITS PREVENTION.

Dampness in walls and floors is usually due to bad construction and neglected repairs. It may arise from leakages from the roof, or the wall surfaces, or from the absence of damp-resisting courses. Even where a damp-resisting course exists, its presence may be nullified by the outer ground being piled against the wall above the damp-resisting course level.

Leaky Roofs.—A slate or tile displaced or missing from a roof will form a direct inlet for rainwater, which runs down the roof boarding to the wallhead, where it spreads in every direction, soaking the wall. Succeeding frosts and thaws expand the moisture and displace the stones or bricks and mortar, every frost leaving wider gaps for a more powerful attack during the next frost. Roofs of all kinds should be examined regularly and repairs made without delay.

Damaged Gutters and Rain-Pipes.—Broken, cracked or choked gutters in roofing are also disastrous to the security of the building if neglected, as water not only runs down the wall face but lodges round the foundations, further aggravating the damp in the walls, which ultimately spreads to the flooring inside the building. All cast-iron and zinc rain conductor pipes should be examined carefully for cracks after a hard frost. These cracks often take place on the surface of the pipe next the wall, and are not easily observed. Such cracking sometimes originates from a choked bend at the foot of the conductor pipe, causing the pipe to stand full of water, which becomes frozen, expands, and thereby does damage. The absence of gutters and down pipes is always false economy.

The Absence of Damp Courses.—The damp-resisting, or, as it is often called, "damp-proof" course in a wall will be of little use unless it is of the proper description and in the right position. In erecting a new building care should be taken to keep the damp-resisting course above the ground level and below the floor level, where at all possible. The wall should be carefully levelled and made free from loose, rough stones, bricks or pebbles. Everything sharp, which is likely to cut through the course after pressure is brought to bear upon it, should be carefully removed. It is a good plan to level-up in preparation for the damp-resisting course with a coat of cement mortar, finished smooth.

For agricultural buildings two classes of damp-resisting course can be recommended. They are (*a*) a layer of British or liquid asphalt about ⅜ inch thick, poured in a hot liquid state upon the walls. This is composed mainly of Archangel tar, a percentage of pitch, and thinned to the proper consistency with a coal tar oil. It should be neither too brittle nor too soft. If the former, it is easily cracked and becomes useless, and if too soft it squeezes out when the weight of the building comes upon it; (*b*) a ready-made rolled damp-resisting course of good quality will be found more serviceable, more reliable, less easily misapplied and certainly much quicker in execution, as no boiler is involved and the work may be stopped at any stage and renewed when found necessary. Many types of such courses are available, a bituminous sheeting with a good canvas core being the best. There are many other types of damp-resisting courses, but they are hardly suitable for agricultural work, either by reason of their nature or their cost. Sometimes, in slate-producing districts, effective courses are made from thick slates embedded in cement mortar. These need to be in two or three layers, with all joints broken bonded. In any case, their great fault is that they are full of joints. Mineral rock asphalt, or Limmer rock asphalt, is very satisfactory, but is too expensive for anything but high-class buildings. Glazed earthenware tiles are occasionally used. These are specially made for the purpose, and are sometimes perforated in order to act as ventilators for wooden floors. They should be embedded and jointed in fine Portland cement as closely as possible. They are open to objection by reason of their joints, and in any case are too expensive for ordinary agricultural work.

Retaining Walls.—On some sites it is impossible to avoid the ground being higher than the floor level at one or more sides of the building, and where this state of matters exists the wall supporting the high soil is known as a "retaining wall." In such cases the earth or rock should not come in direct contact with the wall of the building, otherwise it will be impossible to prevent surface water and subsoil water running from the higher ground to the retaining wall, which will act as a dam and consequently be constantly in a wet state. There are various methods of preventing or curing such dampness. The simplest is to form a trench down to the level of the bottom of the foundation, laying a field drain with proper runs and outlet at the bottom, and filling up the whole space with clean, dry, broken stones or bricks, which should be carefully hand-packed. The top of these stones at the ground level should be covered with cement concrete, extending the full width of the trench. An

additional precaution may be taken by coating the whole outer surface of the wall up to and about 6 inches above the ground level with Portland cement plaster, preferably treated with a good waterproofing liquid, or, alternately, the same surface may be covered with vertical asphalt, although such work is not worth executing unless the material used is mineral rock asphalt, and this method is probably too expensive.

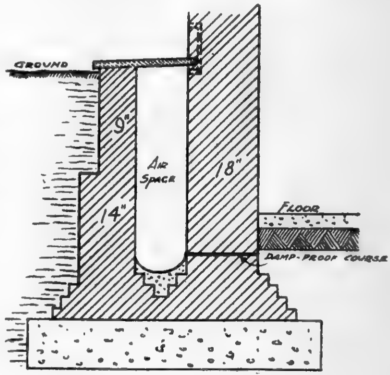


FIG. 86.—Section through a wall adjoining high ground with a dry area covered and ventilated.

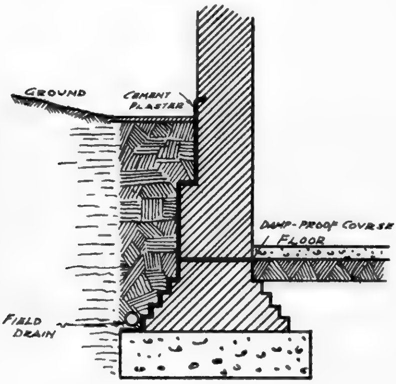


FIG. 87. — Section of a retaining wall with cement or rock asphalt vertical course and asphalt damp-proof course. Note the field drain covered by dry stone infilling.

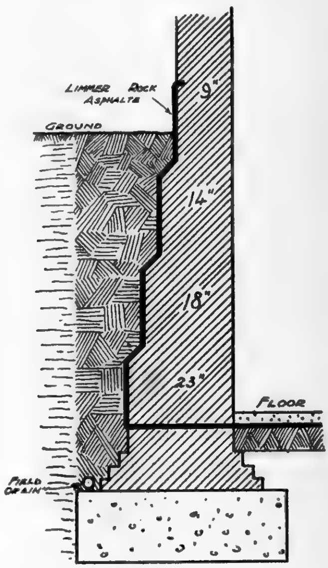


FIG. 88.—Type of retaining wall for a building with very high adjoining ground. The damp-proof course is carried under all the floor and jointed carefully to the vertical asphalt.

A method which may be adopted for new retaining walls is to build the wall hollow, particularly in the case of brick walls, and to form an outside dry area as wide as possible by building the actual retaining wall clear of the building. The bottom of this area should have a properly constructed cement or tile channel, which must be below the floor level and damp course level, having proper outlets for any water which may gather, the outlets being arranged in such a way that chokage is impossible. Such dry areas must be covered over at the top and properly

ventilated. Figures 86-88 show various systems which may be adopted.

Rain-Damped Walls.—Walls exposed to the prevailing wet wind are usually damp during the rainy seasons. In new buildings this danger may be provided against by building the wall hollow, covering the outside with a coat of cement plaster waterproofed with a good waterproofing solution, or by covering the outer surface of the brick wall with slates or shingles nailed to wood laths. Hollow brick walls should be carefully built. The outer thickness need not be more than $4\frac{1}{2}$ inches if built in cement, the main part of the wall being inside. This arrangement provides a substantial support for the roof, and bears the wear and tear which is constant inside agricultural buildings. The cavity between the outer and inner walls should be about $2\frac{1}{2}$ inches, properly ventilated at the top and bottom, with galvanised louvred gratings to prevent the entry of rain and vermin. Galvanised malleable iron ties must be carefully built between the wall and its outer casing, using at least two ties to every superficial yard of work. These ties have a twist in the middle to prevent moisture from travelling across to the inner wall. During the erection of hollow walls, care must be taken that the mortar does not drop down on to the ties nor to the bottom of the cavity. This may be prevented by hanging laths in the cavity, and draw-

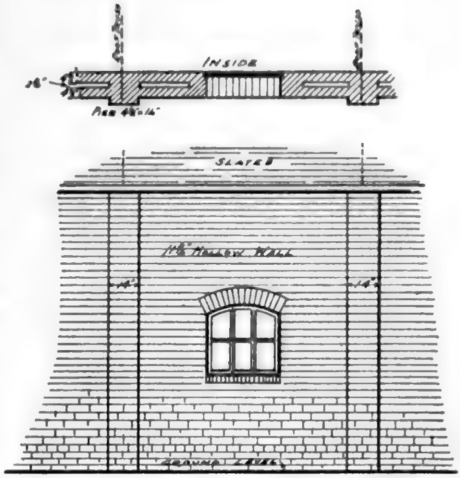


Fig. 89.—Plan and elevation of a 12 inch thick hollow brick wall with piers outside and occurring at each roof truss.

Fig. 90.—Plan of 16 inch thick hollow brick wall with piers on inside face.

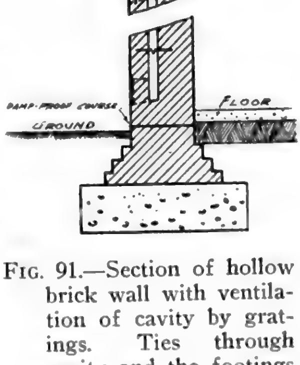


Fig. 91.—Section of hollow brick wall with ventilation of cavity by gratings. Ties through cavity and the footings and damp-proof course are shown.

ing them up as the building proceeds. Hollow walls are doubly beneficial; they keep the building dry, and they also keep it warm by reducing the amount of moisture to be evaporated.

The heating of animal habitations will always be a matter of great difficulty, owing to the expense involved; in fact, the heating of cow byres is usually accomplished by reducing the ventilation and raising the temperature of the byre by conserving the heat given off by the cattle, a method which is detrimental to the health of the animals and strongly to be condemned. Hollow walls are peculiarly suitable for cow byres and other animal habitations in this connection.

THE RECONSTRUCTION OF INSANITARY BUILDINGS.

The conversion of insanitary animal-houses into buildings that will meet with modern requirements is not the least difficult of the veterinary hygienist's problems. The reconstruction of buildings may be very simple so that but little alteration may effect a great improvement or the necessary renovation may be so great as to require practically a complete remodelling. Unfortunately, in many cases where a cow-shed has been " improved " and altered at considerable expense the most important points have been neglected, while undue attention and unnecessary money have been expended upon non-essential details. Occasionally mistakes are committed that show an astonishing ignorance of modern hygiene. Thus in a small byre on a private estate that was " reconstructed " by a contractor, the length of the stalls was measured from the front of the mangers instead of from the wall so that they were made 2 feet too long, with the result that it was impossible to keep the cows clean. The standings were made level throughout so that they were constantly wet. The dung channel was laid with insufficient gradient. These and many lesser defects combined to spoil what might have been a most satisfactory cow-shed. Want of knowledge concerning modern ventilating methods often leads to unfortunate errors on the part of the proprietor. For instance, when roofs are rebuilt, instead of taking advantage of the occasion to make simple yet efficient ventilation at the ridge, usually a few T tile ventilating cans are deemed sufficient, as was the idea a century ago.

Animal-houses may be condemned as insanitary for a variety of reasons. It may be that their location in a city is undesirable owing to their contiguity to human dwellings, together with their general insanitary condition. Reconstruction in such instances is often out of the question and the buildings have to be vacated. In

the majority of cases, however, structural alteration, within reasonable limits, will remedy the defects.

The common faults to be found in old byre and stable buildings include insufficient cubic space, lack of ventilation and light, underground drainage or the presence of gully traps within the building, insanitary and worn floors, narrow and low doorways, dampness, draughtiness, bad proportion of stalls and standings, passages too narrow, rough walls and partitions, complicated roof trusses and many minor defects. A badly-constructed dung pit or its too close proximity to an animal-house or to a milk store is a fault that is very common.

While sanitary authorities are beginning to take a more active interest in the condition of cow-sheds, the housing of horses and other animals receives little attention from them, provided that a nuisance to the public is not caused. Complaints are usually limited to the condition of the dung pit and to the length of time that manure is stored on the premises. Fortunately, the modern owner of animals is taking a more intelligent interest in the welfare of his stock, and improvements are made without the intervention of the sanitary officer.

Where structural alteration and general improvement is desired, a most careful survey of the whole premises should be made so that the reconstruction may be done with the greatest advantage and the least expense. No alteration or improvements should be recommended without there being sufficient reason, and the most important alterations must be given first consideration. Plans and elevations of the buildings should be prepared with all suggested alterations shown thereon, and due consideration must be given to the relation of one building with another, and the effect any alterations will have not only on the health of the animals, but also on the labour involved in tending them.

Air-Space.—Probably the most common of all defects in existing animal buildings, and certainly the most difficult to remedy, is the lack of sufficient air-space for the animals the building is intended to hold. As a rule this is caused by the passage behind the animals having been made too narrow, that is to say, the building itself is not sufficiently wide. This fault cannot be remedied without pulling down one of the walls and of necessity rebuilding the roof. The expense involved in such a procedure would in most cases be prohibitive. The net air-space may, of course, be increased by excluding one or more animals from the building, but this does not result in such satisfactory air exchange as would be the case if the building were designed on proper lines. In any case, floor space

thus borrowed is as often as not again filled by animals, or in some cases it is used as a temporary store for hay and such-like. Provided that the building is generally sound and suitable for its purpose, it would be folly to condemn it if the air-space is only a little less than what is desirable.

In most instances it will be found that the ventilation will also be insufficient and, if this is remedied, a more simple and far more important matter, the house should be passed as satisfactory. In some instances it will be found that the air-space can be considerably augmented by heightening the walls. This, of course, would not be thought of unless the roof is faulty and needs rebuilding. It must also be remembered that the height of the walls must not be so increased that the ventilation is interfered with (see Ventilation).

Ventilation and Lighting.—In almost all the older buildings the ventilation is deficient. Not only are the total inlet and outlet areas too small, but the arrangement of both is usually bad and capable of material improvement. Provision for the inlet and outlet of fresh air should be calculated from the table given in the section dealing with ventilation, and certainly *not less* than the minimum there suggested should be arranged for. Inlets for fresh air can be efficiently and cheaply provided by inserting drain pipes in the walls as recommended on a previous page, but it will be found that many proprietors of the old school will object to this free intake of air. If the lighting is also poor it may be found that the most convenient, if not the most satisfactory method of increasing the ventilation is by putting in a number of wall windows. A more efficient method is to install Findlay's ventilating and lighting system. In deciding what measures to adopt the whole circumstances of the case should, of course, be carefully considered. What would be necessary in one instance might be quite uncalled for in another building. At least 3 square feet of glass must be allowed per horse or cow, and this may be increased with advantage. Provision for the escape of the foul air is the important thing to attend to, and this should be done by giving free outlet at the roof ridge (see Ventilation).

Flooring.—The flooring in many cow-sheds and stables is very bad. Often it is composed of soft building bricks or paving slabs which have worn unevenly. In country districts the earth is sometimes the only flooring for stables.

In the preparation for relaying floors, the old floors should be entirely lifted, as patching never pays in any sense. After the old flooring has been removed, the top layer of the soil, which will be found sodden with urine, &c., must be lifted and the solum made

up with clean, broken stones to the required level or run. Avoid making up the solum with rubbish. For the method of laying, and types of floors recommended, see the section on "Floors." When renovating a floor an effort should be made to fill up and round off all corners with cement.

Walls.—Apart from any necessary heightening it will be found that in the majority of old buildings the walls have been left in a rough state inside the building. They will then require to be finished off smooth with cement or covered with tiles to give the necessary smooth, hard face that can be cleaned easily and that will not lodge dirt and dust. All wallheads inside byres and stables should be built up close to the roof boarding, thereby disposing of that troublesome shelf or scarcement on which dust and dirt accumulate, and which is so attractive to birds and vermin. Where the walls are to be cement plastered, the surface and jointing of the old work should be picked out thoroughly, cleaned, finally brushed over with a wire brush and properly washed before the application of the cement plaster. The outer surfaces of walls should be raked out and repointed, and all cracks repaired to prevent the entry of rain and frost. Walls which become saturated by reason of faulty pointing are liable to disintegration and bursting with each severe frost. Repointing, properly executed, always pays in the long run.

Drainage. — Defective drainage is a very bad fault. Underground drains are still to be met with in the older stables. In cowsheds the underground system is uncommon, but a gully trap is often placed inside the building at the end of the dung channel. In every case underground drains and inside traps should be removed and a surface method of draining, as advocated in the section on drainage, installed instead. Surface drainage in cow-sheds or stables may be faulty owing to wrong construction in the first instance, or to subsequent wear and tear. In stables laid with granite setts or cobble stones the drainage cannot be good as the urine invariably collects in little pools and gradually soaks into the ground between the stones or bricks. It is impossible to get good drainage without a properly laid floor, and if this is provided the drainage is a very simple matter.

Manure Pits are often badly placed on a farm or dairy. Sometimes they are too close to the byre or stable, and at others to the milk store. It is often difficult in town byres to find a suitable place owing to scarcity of room. With the smaller class of premises the problem of the location of the manure pit is more difficult than on the larger and more pretentious premises. This is so not only because of the lack of room, but because labour is more difficult

and the mechanical removal of dung and litter as on tramways or overhead lines is not provided for. For this reason the small proprietor likes to have the pit as close to the byre or stable as he can. This arrangement should be discouraged as much as possible, and a site should be chosen that would not be objectionable. The pit itself should be so constructed that there is not a continual leakage of urine across the yard. An effort should be made to conserve the liquid manure.

Grain Pit.—On dairy farms in or near towns where brewing or distilling is carried on the cows are usually fed on wet brewer's grains, and a pit is constructed much after the style of a manure pit on a small scale in which to hold two or three days' supply, or a supply for one day if the brewery is not far distant. As a rule this pit is placed quite close to the byre, and very often to the milk store. There is no doubt that the micro-organisms arising from the dried "draff" lying on the sides, edges and ground around the pit materially contribute to the bacterial contamination of the milk. While such organisms are not necessarily harmful in themselves, it is certain that they hasten the souring of the milk. For this reason the draff pit should be well constructed and placed away from both the milk store and byre and not in the line of the prevailing winds. Draff pits should be lined with good Portland cement plaster, polished on the surfaces, and all corners and angles rounded out.

SECTION VI.

PREVENTIVE MEDICINE.

PREVENTION of the spread of infectious diseases is one of the most important and, at the same time, most difficult duties of the veterinary surgeon, whether he be a private practitioner or engaged in a municipal or state capacity. It is calculated at times to tax the ingenuity and patience of the most resourceful and patient worker.

Each case must of necessity be treated according to its own requirements, and these will be referred to under the heading of each specific disease. There are, however, certain methods of preventing the spread of infection that are common to all diseases, and a consideration of these forms the basis of all preventive medicine.

Naturally there are difficulties to be overcome, and they are due to many causes, among which may be mentioned the great resistance of some infective agents; the insidious nature of many infectious diseases in which the animal may be an active carrier and disseminator without giving any indication of the fact until the disease has become more or less widespread; the constant and wide traffic of animals which favours the spread of infectious maladies, and at the same time increases the difficulty of tracing and controlling the carriers of the infection; the indifference and carelessness with which some stock-owners, fortunately in the minority, regard contagious diseases, and, with what sometimes amounts to criminal negligence, fail to notify the presence of scheduled disease among their stock, or to take such precautions as are incumbent upon them for the safeguarding of their neighbours. Failure to recognise a disease or to suspect its existence has on more than one occasion been the cause of widespread trouble. An outstanding instance of this was the outbreak of foot-and-mouth disease in Ireland, where an unqualified " animal doctor " failed to appreciate the fact that he was confronted with this most infectious of diseases. The diseases normally non-existent in this country, such as foot-and-mouth disease and rabies, may not be detected, especially in their early stages.

The very nature of infective micro-organisms favours their spread. Being minute and light they are conveyed hither and

thither with the utmost ease; being of material substance, they find resting places on all sorts of media that are in turn passed from place to place and animal to animal.

Lack of accommodation often prevents the separation of the sick from the healthy, and the insanitary condition of so many animal houses in which we have to treat our patients militates against our attempts both to treat the disease and to prevent its spread. We do, however, possess one advantage over our medical confrères. We can destroy infective animals and obliterate all traces of infection should it be desirable to do so.

Infection is transmitted from the diseased to the healthy in a great variety of ways. Direct contact with an infective animal is the most patent but by no means the most common method of spreading disease. If it were the chief cause of disease spreading from one animal to another then prevention would be a comparatively easy matter.

Unfortunately, infection is chiefly disseminated by indirect means, and so its control is much more difficult. Any material that has been in contact with an infective animal may carry the contagium. An infective material such as has been in contact with an infective animal may pass the contagium on to other material, which in turn may transmit it to a receptive animal. Disease is carried from diseased to healthy by other animals acting as passive carriers. People may act as passive carriers by conveying the infective material on their hands, clothes, and boots. Vermin, birds, flies and other insects carry infection. Food and water are not uncommonly the culpable agents in spreading disease, and the air and wind are notable transmittors of infection.

The fact that the contagium of disease may enter the body by *inhalation, ingestion, inoculation,* as well as possibly *absorption,* materially increases the difficulties with which one has to cope.

Chief among the measures taken to prevent the spread of infectious diseases are *isolation* of the infected animal and infective material; *notification* of the existence or suspected existence of an infectious disease to a veterinary practitioner and, in the case of a scheduled disease, to the authority whose duty it is to put in motion active measures for the prevention of its spread; *disinfection* of all media likely to hold or to carry infective material and *general prophylactic measures* which should be taken to prevent the appearance of an infectious malady in clean premises or districts.

Isolation. — With the controlled diseases certain specific instructions are issued to the owner of the animal as to what he must do and what he must not do.

Among the most important of the active measures he is to take is the complete isolation of the sick or suspected sick from the apparently healthy. Isolation of the sick in the case of infectious diseases should not be limited to diseases that are under official control.

The isolation of all animals suspected or known to be suffering from any communicable disease is of primary importance, and to be of any value whatsoever must be complete and thorough. Partial or indifferent isolation is very dangerous, as it tends to promote a false feeling of security with consequent laxity in other and more general directions. As already stated complete isolation of sick animals is very often difficult, if not indeed impossible, on many of the premises in which animals are kept. Every effort should, however, be made to see that the isolation is as complete as possible, and that without any loss of time. Not only the animal but all appurtenances belonging to it and necessary for use while the animal is ill, such as rugs, halter, grooming tools, bucket, &c., must be completely isolated from contact either directly or indirectly with healthy stock.

The attendant on the patient must be regarded as equally infective as the patient itself. In many instances in veterinary practice it is most difficult to obtain a separate attendant for one sick animal, but the best should be done with the means at one's disposal.

If it is absolutely necessary that the same man attends both sick and healthy, then the sick must be attended to last, and the attendant must take due precautions to cleanse himself before passing among the non-infected stock. He should be provided with overalls which he should wear only when working among the sick.

The period of isolation must extend beyond the recovery of the animal, and not be lifted until all possibility of infection has passed away. The time limit is in many instances difficult to determine and varies with the different diseases, but it is better to err on the side of caution than to return an animal to the association of the healthy prematurely. Undue haste in this respect often undoes all the good that might have been derived from the previous care and labour.

A great deal of unnecessary disease might be prevented if people gave due consideration to the rights of others and kept their sick animals under proper control and out of the way of doing harm. Mangey dogs, for example, are allowed to roam with perfect freedom about the streets and in any public place.

Distemper is passed from animal to animal by the thoughtless-

ness of the owners, whereas a little heed to their moral obligations would prevent much unnecessary suffering and loss.

QUARANTINE.—Quarantine means the separation of the apparently healthy that have been exposed to the risk of infection from those animals that are healthy and have not been exposed to the risk of infection.

The object of quarantine is to give time to disease that may be latent to become active and obvious.

Since the period of incubation or latent period of the various infectious diseases differs very considerably, a special quarantine period is allowed for each and one that gives a margin of safety. The incubative period of rabies for example may extend to six months, or possibly longer, while on the other hand the quarantine period for foot-and-mouth disease need only be a fortnight or so as its incubative period is very short.

The term quarantine comes from the French *quarante* (forty), and originally referred to the isolation of ships and their crews that arrived at a clean port from one in which there was such a disease as plague or yellow fever.

During the period of quarantine measures are taken to disinfect material that may be infective, and to destroy such as is of no value or which would not repay the cost of disinfection.

NOTIFICATION.—The notification of scheduled diseases is dealt with under the Animals (Notification of Disease) Order of 1910. It is a very necessary part in the process of controlling and eradicating those diseases that are considered sufficiently dangerous as to call for official control. Danger to life of animals or man is not the only reason that certain diseases are picked out for legislative measures. Some diseases, such as sheep-scab, cause widespread trouble and great financial loss if left unchecked, or are subject to spasmodic or partial supervision. Foot-and-mouth disease is another instance where the death rate is low, but if it were allowed to rage unchecked, as a certain misguided portion of the agricultural community apparently desire, the financial loss to the country would be incalculable, due to loss of milk, loss of condition and to abortion, to say nothing of the prohibition of exports that clean countries would insist upon. Notification of the existence or suspected existence of a scheduled disease serves the following purposes :—

It informs a Central Authority of the existence or suspected existence of disease and its location. It brings experts into contact with the disease, and enables them to confirm or refute the suspicion. It puts into operation measures of control such as

restriction of movement of incontacts, isolation of diseased, and disinfection of premises and materials. It enables the authorities to ascertain the origin of the disease, and to trace back other animals that may be infected and be spreading the infection. In the case of such a disease as anthrax, where there may be several deaths in different localities, it may be possible to find circumstantial evidence pointing to one particular consignment of food (such as bean meal made from soil-dirtied China beans) being infected with anthrax spores. Destruction or sterilisation of the food will prevent any further outbreaks.

It draws attention to the presence of disease, and enables people to put in force prophylactic measures that may act as safeguards against the impending trouble.

It is of great value in "inculcating watchfulness upon the general practitioner, and suggesting the need for a definite diagnosis in doubtful cases" (Lewis and Balfour).

It gives information of the extent of any particular disease in the country, or part of the country, so that the authorities concerned with its control may know if the incidence is on the increase or decrease, and consequently relax or make more stringent their regulations.

For the greatest advantage to be obtained from notification it must be done at the earliest moment. Delay or hesitation is to court disaster, as it gives time for the infective material to become disseminated among the healthy animals. The slightest suspicion that a notifiable disease exists should be sufficient incentive to give notification of the fact to the proper authority. Some diseases are not so easily diagnosed as might be thought from their text-book descriptions, and at times appear in atypical forms. Others again appear but rarely in this country, such as foot-and-mouth disease and rabies, so that the general public, and even the veterinary practitioner, might not recognise the disease from their imperfect knowledge of it. With any suspicion that a notifiable disease is present, the onus of the responsibility of deciding whether or not one has to deal with a scheduled and dangerous malady should be put upon the experts whose business it is to make the decision. If after notification has been made the suspicion turns out to be unfounded, then no harm has been done, unless undue alarm has been raised, but if there has been any delay in reporting the suspected existence of such a disease as foot-and-mouth disease and it is present, then the result may be very serious.

Apart from the notification of scheduled diseases every stock-owner in his own interests should consult a veterinary practitioner

without delay, if he suspects the existence of other infectious maladies among his animals, as the veterinary surgeon can give advice and directions calculated to check the further spread of the trouble. In a great many instances owners of animals adopt a procrastinating attitude that is fatal to the welfare of their stock and harmful to their own personal interests.

Failure to give prompt notification of the suspected presence of a scheduled disease by a veterinary practitioner or owner of an affected animal is punishable by a fine, and in some instances by imprisonment.

Prophylaxis.—Prophylactic measures are the means taken to prevent as far as possible the appearance of disease. While the term is generally applied in connection with infectious diseases the steps taken to prevent the onset of any preventable disease are also prophylactic in character. Thus, the restriction of the diet of working horses during idle days is a prophylactic measure against azoturia and lymphangitis.

With the infectious diseases that are under official control prophylactic measures are put into force by the authorities concerned, the Ministry of Agriculture and Fisheries, and the Local Authorities. In the case of diseases that are not scheduled as notifiable diseases prophylaxis is dependent upon the foresight of the owners of stock and that of their veterinary advisors. For the maximum benefit to be obtained from prophylaxis the active steps must be taken, in the case of an infectious trouble, before the disease has made its appearance in a district or premises.

The measures include publication of the fact that a disease has appeared in a certain area, so as to give warning to other people in order that they may take further action to guard against the trouble.

The Local Authorities have the power to advertise in the public press, to post notices in public places, and to placard the infected premises. Public notification of the existence of an infectious disease is of undoubted value, but care should be taken to avoid the causation of undue alarm. With the information to the public that a specific and infectious disease exists among stock, or is likely to appear owing to its proximity in another district, advice should be given by competent persons as to the best methods to be adopted to keep their premises and animals clear of infection. Unnecessary traffic among neighbouring farms or stables should be avoided, premises should be kept clean, animals should be well attended to; they should be well fed and not overworked.

Naturally prophylactic details differ with the character of the

various diseases, and these are discussed under their respective heads. Vaccine and Serum Therapy are of value in certain specific instances.

CLEANSING AND DISINFECTION

DISINFECTION means the conversion of a place, person, or thing from a potentially infective state into one which is free from infection. This implies the destruction of pathogenic micro-organisms and their spores.

As micro-organisms find temporary resting places in and are hidden by dirt and dust, *cleansing* of infective material is a necessary combination with disinfection.

A *Disinfectant* is an agent that destroys pathogenic organisms and their spores.

An *Efficient Disinfectant* is one which does the work required of it within a reasonable limit of time.

A *Suitable Disinfectant* is an efficient disinfectant that does not materially damage other substances with which it is brought in contact, and which is especially adapted to the particular purpose for which it is used.

An *Antiseptic* is a substance or agent that temporarily inhibits or retards the growth and multiplication of micro-organisms.

A *Deodorant* is a substance used to remove or correct offensive odours.

Disinfectants may be *Physical* or *Chemical*. Among the former are wind, sunlight, heat, and electricity. The latter may be in the form of gases, solids, or liquids.

Fresh air and *wind* are germicidal, though their action is slow. Fresh air has an oxidising effect, which is enhanced if it is well charged with ozone. Both fresh air and wind dry up moist dirt that holds bacteria, and a drying wind dessicates micro-organisms. Wind and fresh air entering an inhabited building dilute both the excretory products of animals and the concentration of bacteria in the air.

Direct sunlight is a disinfectant in virtue of its violet and, more especially, its ultra-violet rays. These rays are arrested by ordinary window glass, so that sunlight transmitted through closed windows has not the same power as if it passed through an open or unglazed window. The rays are soon held in water, especially if the water is turbid and holds much solid matter in suspension. Sunlight has an oxidising and drying effect, so, while not necessarily a powerful

disinfectant, it is a valuable "cleanser." The combined action of fresh air and sunlight is by no means to be regarded as negligible.

Heat is one of the most valuable disinfectants we have.

Electricity is used to some extent for the sterilisation of milk, and also sometimes for the purification of water. With these possible exceptions its use is limited, so far as concerns veterinary practice.

DISINFECTION BY HEAT.

Heat is used in two forms, dry and moist.

Dry Heat.—Most vegetative forms of bacteria and those which do not sporulate are killed off if exposed to a temperature of 150° F. for about ten minutes. Dry heat might therefore be of value if one could be certain that the more resistant forms of bacteria are not present, and if one could be sure that all the organisms in an article to be disinfected would be exposed to this heat. Unfortunately one has to deal with highly resistant spores, and the penetrating power of dry heat is very poor, so that though bacteria on the surface of goods may be destroyed this is not the case with those that are buried in the depths of closely woven articles or in between layers of rugs. It has, furthermore, been found that as high a temperature as 212° F. for a period of an hour fails to destroy even non-sporing forms, if these are in a dry state when exposed. Dry heat, therefore, is of no practical value for the disinfection of such articles as horse rugs and the like, as these would be scorched if the heat is great enough and the period of exposure long enough for all the pathogenic organisms to be made harmless.

Dry heat in the form of a live flame is, however, a most valuable agent for the disinfection of things that would not be damaged by its use. The cremation of dangerous bedding and excreta, of soiled halters, sponges, rags, and such things of no great monetary value is the surest way of disposing of them. A painter's or brazier's lamp is the most useful "disinfectant" at the disposal of the veterinary hygienist, and here he possesses a great advantage over his medical confrère. The flame can be applied to almost any part of a stable or byre without doing injury.

A splash of anthrax blood on the travise in a cow byre can in a few moments be made harmless *with certainty* if burned with the flame, whereas there is always a possible element of doubt when chemical disinfectants are used.

Shovels and forks used in the cleaning up following anthrax or other dangerous disease can be treated in the same way. Curry combs used on mangey horses are made safe beyond any question of

doubt if subjected to a good flaming, and no harm is done to them. Stall partitions, mangers, and other fittings can be flamed with the lamp, and the heat can be made to penetrate into all the cracks and crevises without damaging the material. Many other instances of the practical utility of the flame could be given.

MOIST HEAT.—Moist heat is used as hot water, moist air, and steam.

Hot Water.—The momentary application of boiling water to germ-carrying articles is not disinfection, but if such articles can withstand actually being boiled for twenty minutes or so, then disinfection does occur. With ordinary atmospheric pressure the spores of pathogenic bacteria are killed off in about ten minutes, but boiling an article for ten minutes or thereby is quite another matter from the passing application of boiling water. When boiling water is used for the scouring out of mangers and similar stable fittings this must not be regarded as having any germicidal action. In the first place the period of contact is much too brief, and, in the second place, though the water may be boiling when put into the bucket it soon cools, and by the time it has come in actual contact with the manger or travise it is many degrees below boiling point. The application of hot water, especially if it contains soda, is, however, very useful owing to its cleansing action. The scalding of fittings, &c., should be looked upon as an adjunct to disinfection proper. In some instances, as when anthrax blood is spilled on a byre floor or on a travise, such preliminary scalding is contraindicated. The blood must be made harmless before it is removed.

Some articles of clothing can stand being boiled, but the boiling fixes such stains as blood, and tends to spoil the appearance of the goods.

The boiling of metal articles such as surgical instruments has for long been the recognised method of effecting sterilisation. The rusting of metal that sometimes occurs can be prevented by boiling the water for some time previous to immersion of the articles.

Water boils at 212° F. at sea level, that is with a barometric pressure of 30 inches. The lower the atmospheric pressure the lower is the "boiling point," so that boiling water at a level much above that of the sea would not have the same potency as a bactericide as it would on a lower level with a higher air pressure. Conversely, the higher the air pressure the higher is the boiling point, thus water boils at 249° F. when the pressure equals two atmospheres or 30 lbs. to the square inch. Water containing a saline such as calcium chloride or carbonate of soda also boils at a

higher temperature than pure water, 225° F. as against 212° F. Steel instruments do not rust if boiled in a solution of sodium carbonate.

Steam.—Steam is used as ordinary steam, superheated steam, under pressure greater than atmospheric pressure and under reduced pressure.

The temperature of steam at ordinary atmospheric pressure, *i.e.*, 15 lbs. per square inch, is 212° F. (100° C). Most spores, if kept in direct contact with steam at this temperature for ten minutes, are destroyed.

Hot dry air has very little penetrating power, and so it is that organisms contained within folds of rugs and other materials that are bad conductors of heat are not affected, unless the temperature is such as will damage the more superficial layers. Hot dry air on coming into contact with cooler substances has its temperature reduced, as a certain amount of the heat is used up in the evaporation of the moisture that all "air-dried" substances contain.

With steam there is no reduction of heat, as evaporation of the moisture obviously cannot take place. Instead of there being a reduction of heat there is, on the contrary, an increase owing to the amount of latent heat contained in steam. Steam on coming in contact with a cooler substance undergoes condensation, and the latent heat set free as condensation takes place is available for heating the cooler body.

Thus, in fact, steam on condensation has more available heat than it had in its original form. The latent heat of steam is the heat or energy expended in converting water at the boiling point into steam. At ordinary atmospheric pressure both the steam and the boiling water have the same temperature, 212° F., and yet the steam contains, in a latent form, extra heat, which it parts with on condensation.

The penetrating power of steam is very great, and it is brought about in this manner. Ordinary or "saturated" steam condenses into a comparatively small volume with a very slight degree of cooling. On coming in contact with, say, a bundle of rugs, it warms and penetrates the outer layer, undergoes condensation and reduction in volume with the formation of a partial vacuum as a natural consequence, more steam rushes in to fill the vacuum, which, in turn, passes on into the interior to fill the vacuum caused by the steam that has gone on before.

Steam heats irrespective of whether the material to be disinfected is a good or bad conductor of heat, which is not the case

with hot dry air whose penetrating power is limited by the conductivity of the article.

Superheated steam is steam that has a temperature higher than that of ordinary or saturated steam under equal atmospheric pressure. It may be made by increasing the temperature of the steam, without altering its pressure, by surrounding the chamber in which it is contained with a second chamber or jacket into which is passed steam under an increased atmospheric pressure, and thus having a temperature higher than the steam in the inside chamber. The inner steam is therefore heated by borrowed heat from the outer steam; this increased heating also drys it.

The temperature of steam can also be raised by generating it from a saline water the boiling point of which is 225° F., as compared with 212° F. of ordinary water. This fact is put to good account in practical disinfection as in Thresh's disinfector.

Saturated steam condenses at the slightest reduction of heat. Superheated steam, on the contrary, cannot condense until it has lost by conduction its " superheat."

Steam that has been superheated by passing it over hot pipes or surrounding it with a jacket containing steam under increased atmospheric pressure, is, as has been said above, much drier than ordinary or saturated steam, and is rather a hot gas than steam. Owing to its dryness its germicidal power is much less than saturated steam.

Steam under Pressure.—Variation in the pressure under which steam is generated can only be effected in an air-tight container or boiler, since the altered pressure would soon revert to the normal, if not in fact impossible to obtain, if there were any continuity with the air at general atmospheric pressure. Alteration in pressure may be either an increase or a decrease. When water is boiled in a sealed vessel, which is necessarily fitted with a safety valve and a pressure gauge, the steam accumulates and, as more steam is formed, undergoes compression by the ever-increasing volume. The pressure within the boiler is therefore greater than that of outside air and, as has been said, water boils at a higher temperature as the atmospheric pressure increases. The temperature of the steam produced under pressure is therefore greater than that produced at ordinary temperature, as the temperature at which the water boils is greater.

Unlike superheated steam, " pressure steam " is still saturated with moisture, it is not dried, and possesses therefore the great advantage of increased heat over ordinary steam, and is free from the disadvantage of dryness inseparable from superheated steam.

Steam under pressure is in constant use in laboratories for the disinfection of materials used in bacteriological work and for the disinfection of instruments.

Steam under Reduced Pressure.—The temperature of steam can be reduced by lowering the pressure under which it is generated. The lower the temperature the less is the germicidal potency, so that " reduced steam " by itself is of no value for practical disinfection. As ordinary steam may be deleterious to certain goods, reduced steam may be used, and the deficiency brought about by lowering temperature made up by combining with it such a substance as formaldehyde.

There are various steam disinfectors on the market, some fixed, such as are used by municipalities for the disinfection of clothing from infectious houses, and others that are portable or built on wheels for the convenience of transport, as may be required under such conditions as warfare. The use of current steam gives the best results, as the steam being drawn through the machine containing the articles displaces and drives before it the air contained in the folds and interstices of clothing, &c. This naturally facilitates the penetration of the steam.

Saturated steam under a pressure of 10 lbs. above normal atmospheric pressure has a temperature of 240° F., and being under increased pressure has great penetrating power, and good results are obtained from its use. An exposure of twenty minutes is sufficient to ensure the destruction of both bacteria and spores even in folded blankets. After this exposure the steam is shut off and a current of hot air is forced through; this thoroughly dries the goods which come out none the worse for the treatment. Such articles as leather are, however, spoiled. Cotton, woollen, and linen fabrics stand the steam and heat well. Blood and similar stains are unfortunately fixed.

With Thresh's disinfector increased pressure is not used, but the temperature of the steam is raised above that of ordinary steam by using a saline fluid that boils at 225° F.; current steam is used.

During the 1912 outbreak of foot-and-mouth disease in Ireland all the stacks of hay on farms near the scenes of outbreaks were disinfected by the agency of superheated steam. Steam was injected from an engine into the ricks to a depth of 1½ to 2 feet. The heat penetrated to a depth of over 3 feet. Repeated tests with a thermometer showed a temperature of 220° F.

It was found that this process did not damage the hay in any way. The day after the steaming the hay was found to be quite

dry, the outside of the ricks showed a brownish appearance as if the hay had been boiled.*

CHEMICAL DISINFECTANTS.

Chemicals act as disinfectants by reason of (1) their oxidising power; (2) their reducing power; and (3) their corrosive and coagulant effect on the albumen of bacteria and parasites.

The conditions under which the various chemicals are used affect to a very marked degree their potency. All solutions of disinfectants should be made with clean water. Moderately soft water, that is water not containing more than 12 parts of calcium carbonate per 100,000, is much to be preferred to a hard water. This is especially important when the disinfectant has a cleansing action as is the case with *Liquor Cresolis Saponatus* and similar preparations. In making a solution of a desired strength it is important that the quantities of water and the disinfectant are accurately measured and not guessed. No other chemicals must be added than the one it is desired to use. The combination of two or more disinfectants, so far from increasing the potency of the solution, may bring about chemical reaction with the production of inert new substances. The vessel in which the solution is made must be clean, and the reagent used must be thoroughly mixed with the water and not merely added to it. In selecting a disinfectant careful thought should be given to the purpose for which it is to be used. Some disinfectants are rendered inert, or nearly so, in the presence of much albuminous material, such, for instance, as perchloride of mercury and potassium permanganate. Others are especially suitable for the disinfection of floors, walls, &c., which if used on harness, clothing, and the like would speedily destroy them. Formaldehyde, for example, has a tanning or drying effect on leather. Bleaching powder, one of the most powerful and useful disinfectants the veterinary surgeon can use, is destructive to harness and clothing if used too strong. The time factor is important, and a sufficient period must be allowed to elapse for the disinfectant to do its work. Temperature has a great influence upon the potency of disinfectants. A solution of a disinfectant (except bleaching powder) in hot water is much more powerful than one made with cold water—" Some idea of the magnitude of the effect of temperature may be gathered from the fact that with metallic salts the mean velocity of disinfection increased two to fourfold for a rise in temperature of 10° C, while with phenol it

*(Report of Foot-and-Mouth Disease in Ireland, 1912. Cd., 7103.)

was as high as eightfold, using *B. paratyphosus* as test organisms in each case."*

Perchloride of Mercury (Mercuric Chloride, Corrosive Sublimate, $HgCl_2$).—Perchloride of mercury for a long time held first place among disinfectants both for surgical and general use. It is now generally recognised, however, that though it is a very powerful bactericide, that is to say, it can destroy micro-organisms in a short space of time even in very dilute solution, its practical use is far more limited than was formerly thought.

Corrosive sublimate is soluble in 18 parts of water, but for general disinfection purposes is rarely used in greater strength than 1-500, while 1-1000 to 1-2000 are strengths more commonly used. When the salt is dissolved in water the molecules of $HgCl_2$ do not remain as such but undergo ionisation to separate atoms of mercury and chlorine, one molecule of the salt splitting into one atom of mercury and two atoms of chlorine.

The mercury ions are positively charged and the chlorine ions negatively. The ionisation is, however, never complete, and a certain proportion of the perchloride molecules remain in solution as such. The disinfectant power of this metallic salt is chiefly due to the free mercury ions which, coming into contact with the protoplasm of the bacteria, unite with it to form the insoluble *albuminate of mercury* to the destruction of the organism.

The free chlorine ions also possess a disinfectant action, but their power is less than that of the mercury. Since it is the free mercury ions that actually destroy the bacteria, the potency of any solution of corrosive sublimate depends upon the ionisation that has taken place. Any substances added to the solution, therefore, that tend to hinder ionisation reduce the utility of the salt. The ionisation, however, may be increased by the addition of a small amount of an acid. The potency of the Seymour-Jones Formic-Mercury process of disinfecting hides is largely due to the action of formic acid. Tartaric acid is often combined with the corrosive sublimate for the purpose of increasing its action when it is made up in the tablets of commerce that are so frequently used. Hydrochloric acid is often used to acidify the solution, and the Local Government Board recommends the following:—corrosive sublimate, $\frac{1}{2}$ oz.; hydrochloric acid, 1 oz.; aniline blue, 5 grains; water, 3 gallons. This gives a strength of about one of the sublimate to 980 of water.

Common salt, though it has its uses when combined with the mercury salt, as will be explained later, actually hinders free ionisa-

* *Handbook of Antiseptics,* Dakin and Dunham.

tion by liberating an excess of chlorine atoms in the solution. An alcoholic solution of perchloride of mercury has a germicidal action that is practically limited to the action of the alcohol, since little ionisation takes place in the presence of the alcohol and the molecules remain intact or nearly so. The salt is said to preserve its disinfectant powers in fats or oils, as it is only feebly soluble in them and therefore leaves them readily for the fluids of bacteria (Cushny).

Since perchloride of mercury is germicidal by virtue of the affinity of the free mercury ions for albuminous material, it follows that if a solution of the salt is brought into contact with organic matter containing albumin much of its strength will be expended upon the harmless substance, while the bacteria may escape its action. Its use as a disinfectant of animal excreta is still further contraindicated owing to the presence of the potassium and sodium chlorides. Perchloride has a corrosive action on metals, the mercury becoming deposited. It is therefore useless as a disinfectant for instruments or for disinfecting metal work, such, for instance, as the iron or brass work of stalls and other fittings. Not only does the mercury spoil the metal but, being deposited, is not available for action on the bacteria.

Muir and Ritchie* state that the perchloride in a strength of 1-100 will kill anthrax spores in twenty minutes, although an hour's exposure to 1-1000 has no effect. According to these authorities the best results are obtained by the addition to the sublimate of ·5 per cent. of sulphuric or hydrochloric acid, when the spores will be killed by a seventy-five minutes' exposure of a 1-200 solution. With regard to the vegetative forms, they go on to say that anthrax bacilli in blood will be killed in a few minutes by 1-2000, in bouillon 1-40,000, and in water 1-500,000. "Generally speaking, it may be said that a 1-2000 solution must be used for the practically instantaneous killing of vegetative organisms."

Corrosive sublimate is conveniently put up in tablet form so that dilutions of any strength can be made with accuracy and without delay. Common salt and some colouring matter, usually eosine or methylene blue, are incorporated. The former is added to increase solubility, but as the presence of sodium chloride in the solution tends to hinder ionisation of the mercuric salt, the amount of salt added to the tablet should be limited to the minimum required. The salts are usually combined in equal proportion. Tartaric acid is added to increase the electrolytic dissociation when in solution. Colouring matter is added to give a distinctive colour

* *Manual of Bacteriology*, London, 1919, p. 171.

to the solution; this is important as an aqueous solution of this poisonous salt has neither colour nor smell.

Bleaching Powder ("Chloride of Lime," Chlorinated Lime, Calx Chlorinata).—The exact chemical composition of bleaching powder, which is sold for disinfectant purposes as "chloride of lime," is not known, beyond the fact that it consists of calcium chloride and calcium hypochlorite. The common commercial product oftens contains impurities, especially an excess of calcium chloride. It is made by passing chlorine gas over slaked lime; when the chlorine has been apparently taken up, excess of the lime is added for safety before the bleaching powder is removed. It occurs as a white or greyish powder with a distinctive unpleasant smell. It is poorly soluble in water, but mixes with it to form a cream. Bleaching powder possesses powerful oxidising and deodorant properties, and owes its germicidal action to the liberation of nascent chlorine gas and nascent oxygen. The utility of bleaching powder therefore depends upon the amount of "available chlorine" it contains, and this should not be less than 30 per cent. This amount is specified as the minimum when the powder is used as a disinfectant under the regulations of the Ministry of Agriculture. Bleaching powder is unstable, and is liable to decompose with reduction in the amount of nascent chlorine; if kept in the damp and exposed to light and air the decomposition is more rapid. This explains the necessity of standardising its strength. It is used either as a solution poured on to the substance to be disinfected or by generating chlorine gas from it for aerial disinfection. Being very destructive to organic matter, it is of the greatest value in veterinary practice for the cleansing and disinfection of stable floors and the like. It speedily dissolves sputum and other albuminous material, and its use is therefore indicated on anthrax-infected bedding and manure, and for disinfecting premises and equipment following an outbreak of foot-and-mouth disease. Unfortunately it cannot be used about dairies or in byres where milking is done owing to its liability to taint the milk. A 10 per cent. mixture of the powder with water may be depended upon to destroy anthrax spores if the available chlorine is 30 per cent. It should be mixed immediately before use, and this should be done by making the powder into a thick cream with water and then diluting to the desired strength. A 1 per cent. solution may be used to wash clothes, and in this strength is germicidal, but it is doubtful if it would destroy anthrax spores. Such a mixture may be used for the disinfection of soiled rugs and bandages, and it possesses an additional advantage in that it removes stains by its bleaching

action. Care must be taken that the solution is not stronger than 1 per cent. nor the powder imperfectly mixed, else corrosion of the cloth is sure to occur, and even at this strength some bleaching will take place.

Bleaching powder is a valuable disinfectant for polluted water (see Disinfection of Water).

When bleaching powder is mixed with water it splits up into calcium chloride and calcium hypochlorite :—

$$2CaOCl_2 = CaCl_2 + Ca(ClO)_2$$

The hypochlorite is acted upon by the CO_2 of the air and water with the formation of calcium carbonate and hypochlorous acid :—

$$Ca(ClO)_2 + CO_2 + H_2O = CaCO_3 + 2HClO$$

When the hypochlorous acid comes in contact with organic matter it splits up into HCl and O. It should be well understood that " chloride of lime " acts by *oxidation,* not by *chlorination.*

The calcium chloride that is left behind is a deliquescent powder, so that after disinfection is complete it should be washed away. It also has an errosive action on metal pipes; for this reason traps and pipes should be well flushed out following it use.

LIME (Calcium Oxide or Quicklime, CaO).—Quicklime results from the ignition of the carbonate of lime. It is a greyish-white substance. It combines with water with the evolution of great heat, swells up and crumbles into a fine powder, calcium hydroxide or " slaked lime " $Ca(OH)_2$. Freshly burned quicklime is an absorbent, and dehydrates organic matter. It is a disinfectant of some value, but its action on sporulating organisms is uncertain. When quicklime is left exposed to the air it absorbs moisture and becomes " air-slaked " and practically useless. Freshly burned lime should always be used, and lime that slakes badly is of inferior value. Quicklime is used in practical disinfection, chiefly in connection with the disinfection of fæcal and other organic matter; it should be well mixed with it and left for several hours.

SLAKED LIME (Calcium hydrate, $Ca(OH)_2$). — The most common form in which lime is used is as milk of lime or whitewash. It must be prepared from fresh quicklime of good quality. Quicklime is converted into the hydrate of lime by adding approximately its own weight of water, roughly a pint of water to two pounds of lime. Milk of lime is made by adding four parts by volume of water to one of slaked lime. Milk of lime when it is freshly prepared has undoubtedly a caustic action and is therefore a disinfectant. Whitewash is made by diluting milk of lime with water. Freshly prepared whitewash has a certain germicidal action, but its potency is greatly increased by the addition of a disinfectant of

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known reliability. In fact it is safer to regard whitewash rather as a medium for carrying and applying a disinfectant than as being itself a disinfectant. Carbolic acid or any of the phenol preparations are most suitable for this purpose. Carbolic acid should be added so that the wash contains 5 per cent.; the emulsified coal-tar products, being more potent, should be added so the mixture contains from 2 to 3 per cent. In every case the container in which the whitewash is mixed should have its capacity estimated so that addition of the active disinfecting agent is not a matter of guess work.

Whitewash should never be applied to dirty greasy walls for the purpose of hiding dirt. Previous to application a thorough cleansing should be carried out. The addition of size, salt, fat or alum to the mixture prevents the dried lime from rubbing off.

Whitewash may be applied with a brush or by means of a spraying machine; in either case it is difficult to get the mixture to penetrate sufficiently into the cracks and crevices. When spraying a disinfectant on to walls, stall partitions, &c., it is important to apply the spray with force; this is not possible with whitewash owing to the mechanical nature of the suspension.

Lime, as quicklime or milk of lime, is particularly suitable for use about dairies and cowsheds; it possesses itself deodorant properties, and does not impart an odour to milk which very readily becomes tainted by chloride of lime and some other disinfectants of value.

The following method of making limewash is recommended by the Department of Agriculture of New South Wales :—

Place enough tallow required for the purpose in a large bucket, then lay the same quantity of dry lime on top of the tallow, then enough water to slake the lime. When the heat from the lime has melted the tallow and all is dissolved, stir thoroughly until well mixed; then apply, while still warm, with a brush. The surface must be dry and clean before the wash is applied.

Formaldehyde, Formalin (HCHO).—Formalin is a 40 per cent. solution of formaldehyde gas. It is used as a liquid, a vapour or a gas.

Pure formalin is a colourless liquid yielding a colourless vapour. Some of the commercial formalin has a yellowish tinge. The vapour given off is irritating to the eyes, nose, and throat, and, if sufficient be inhaled, to the bronchi. Compared with other gaseous or vapour disinfectants it is much less harmful to the higher animals, while at the same time it possesses a powerful disinfectant property. Its action is slow and uncertain at a low temperature,

and like other disinfectants it acts quicker if the temperature is raised to 65° F. It has a tanning effect on the skin, and is apt to make leather, such as harness, brittle.

The manner in which formaldehyde acts is not quite clear, but it is known to modify the proteins, and owing to this action objection is raised against its use for the preservation of milk and other food, at any rate for children. Some believe, however, that its action on the food proteins does very little harm. It is possible that if ingested in fairly large doses carried over a considerable length of time, it may have a tanning effect on the mucous lining of the intestines.

Formalin when in solution exposed to dry air undergoes polymerisation to form an inert substance, *paraformaldehyde* or *paraform* $(HCHO)_3$ which may be reconverted to the gas formaldehyde by heat. Paraform tablets are used for aerial disinfection.

Used as a liquid for disinfecting floors, stalls, and the like, it should be applied not weaker than 5 per cent. By a 5 per cent. solution is meant a 5 per cent. solution of the 40 per cent. commercial formalin. As a liquid disinfectant it might with advantage be more frequently used in veterinary practice. According to Muir and Ritchie, in the case of a pure culture a 5 per cent. solution will destroy anthrax bacilli in a quarter of an hour and the spores in five hours. For clothing infected with anthrax bacilli "an exposure to the full strength of formalin for two hours is necessary, and in the case of anthrax spores for twenty-four hours." For the use of formaldehyde gas, see under Aerial Disinfection.

TAR (Pix Liquida, Wood Tar).—Wood tar, also known as Archangel or Stockholm tar, is a thick brown or brownish-black bituminous fluid or semi-fluid obtained by the destructive distillation of wood, chiefly of *Pinus sylvestris* and other species of *Pinus*. The gaseous products of the destructive distillation of wood are carbon dioxide, carbon monoxide, and hydrogen with a little methane. The aqueous portion (crude pyroligneous acid) usually forms from 28 to 50 per cent. of the wood distilled and contains acetic acid, methyl alcohol, allyl alcohol, and acetone as its chief constituents, along with many other bodies in smaller proportions. The tar itself is a complex mixture of various hydrocarbons, phenols, and phenoloid bodies. By the distillation of crude tar are obtained pyroligneous acid, oil of tar and a residue of pitch.

Tar is a disinfectant and preservative, but it is not greatly used in veterinary practice except for the purpose of disinfecting and preserving the woodwork of stables, &c. Even for this

purpose it is not very suitable, as the extensive application of tar in a stable or byre robs the place of much of its light, which is very seldom over-abundant. The use of tar is, however, quite legitimate in open or temporary stables, cattle courts, and the like. Major J. R. Hodgkins, discussing the disinfection of veterinary stables in France during the War, advocates the use of tar "as a complement to other methods of disinfection." Tar takes a long time to dry, and to get over this difficulty he suggests that, after the usual scrubbing with hot water and antiseptic, the fittings should be subjected to the flame of a brazier's lamp. This dries the iron and woodwork. The tar is then applied and afterwards burned with a lamp and scraped away. The wood becomes creosoted. After several tarrings no more need be applied and all that is required is to boil up the existing tar with the lamp and scrape.

Coal Tar (Pix Carbonis).—This is a black viscid fluid of characteristic and disagreeable odour obtained as a by-product in the manufacture of illuminating gas. Coal tar is a body of very complex composition, and is more or less mixed with ammoniacal liquor as well as with the constituents of illuminating gas itself in solution. It is resolved by fractional distillation into (1) light naphtha; (2) light oil; (3) carbolic oils; (4) creosote oils; (5) anthracene oils; and (6) pitch.

Carbolic Acid (Phenol, C_6H_5OH).—This popular disinfectant occurs in commerce in various degrees of purity. What is used in surgical practice is almost chemically pure, *acidum carbolicum* and *acidum carbolicum liquefactum,* of the British Pharmacopœia. The latter is made from the former by adding fifteen parts of water to one hundred parts of the pure acid.

Crude or Commercial Carbolic Acid consists of 95 to 97 per cent. of cresols and higher homologues with but little carbolic acid (phenol). The cresols are at least as valuable disinfectants as pure carbolic acid, and they are the basis of lysol and all similar preparations. There are crude carbolic acids of what is called 25 per cent. strength, *i.e.,* they contain 25 per cent. of cresols and the remainder consists of naphthalene oils which are of no value as antiseptics.

Carbolic acid is obtained from the fraction of coal tar distilling between 150° C and 200° C by agitating with a 20 per cent. solution of caustic soda solution. After standing some time the liquid separates into two layers, the lower one containing phenate or carbolate of soda. This is drawn off, diluted, and exposed to the air, when a brown deposit containing naphthalene is formed. The filtrate is then fractionally precipitated with dilute sulphuric acid,

yielding first some resinous bodies, then homologues of phenol (cresols, &c.), and lastly pure phenol.

The phenol is washed with a little water and then distilled, the portion coming over between 180° and 190° C is collected separately. On cooling phenol crystallises out, and is separated from the liquid portion (cresols).

Cresol or Cresylic Acid. — Cresol is a slightly yellow or colourless fluid with a tarry odour obtained from coal tar.

There are three isomeric cresols (ortho-, meta-, and para-cresol), but the principal constituent of the "crude carbolic acid" of commerce (the source of commercial cresylic acid) is para-cresylic acid with more or less of its isomers. A mixture of the three was introduced under the name of Trikresol. Cresol is the basis of the numerous disinfectants of the lysol class.

Compound Solution of Cresol.—There are various formulæ for this preparation under different names. *Liquor Cresolis Saponatus,* B.P., contains 50 per cent. cresol rendered soluble with castor oil and caustic potash. *Liquor Cresolis Compositus,* U.S.P., also contains 50 per cent. cresol, but linseed oil is used instead of castor oil. The B.P.C. formula is similar to the latter, but has in addition a little alcohol. The German Pharmacopœia gives equal parts of cresol and pale soft soap. This is said to be 3 to 5 times more powerful as a bactericide than carbolic acid and much less poisonous. All these preparations form a clear solution with water and are imitations of lysol, in place of which they may be used. Similar preparations are Sapocresol, Crelium, Phenolin, and Kresapol.

Lysol.—Lysol is a dark alkaline liquid containing about 50 per cent. of cresols. It is miscible with water. It is prepared by mixing linseed oil (or a fat) with oil of tar and saponifying with caustic potash and alcohol. The Lysol Patent specification (expired) gives this formula :—Tar oil 100, linseed oil 100, caustic potash solution (1 in 2) 75, and alcohol 65. Boil under a reflex condenser until saponified, sp. gr. 1·047. A transparent brown syrupy liquid, forming a clear solution with water. It is a solution in neutral soap of tar oils distilling between 187° and 200° C, which are present to the extent of about 47 per cent.

Creolin.—Artmann's Creolin (German patent) is prepared by sulphonating tar oil freed from carbolic acid and extracting with water. The milky liquid is separated into two layers by means of hydrochloric acid or brine, the upper layer being removed for use. Pearson's (English) is a soluble preparation of 20 per cent. cresylic acid rendered soluble by means of soap. It is similar to Jeyes

Fluid and forms a white emulsion with water. Published analyses state that it contains 60 per cent. hydrocarbons boiling at 190° to 350° C, and 10 to 22 per cent. phenols boiling at 200° to 350° C.

Jeyes Fluid is a preparation of tar oils and owes its bactericidal properties to the comparatively non-toxic higher phenols. It is a reliable disinfectant.

Carbolic acid is caustic and coagulates albumen. It is soluble in water up to 5 per cent., and is less soluble in cold than in hot water. It is not a strong disinfectant, but possesses one advantage over many others in that its potency is not reduced in the presence of serum. For long it held premier position as an antiseptic and disinfectant, and it is to-day used as the unit against which other disinfectants are compared and standardised. Ordinary vegetative bacteria are killed in five minutes in a 3 per cent. watery solution. Its action on sporulating organisms is, however, weak, many hours being required for the destruction of anthrax and tetanus in a 5 per cent. solution at room temperature. Neither carbolic acid nor any of its preparations are suitable for use in food stores, dairies or milking sheds owing to the facility with which milk and other foods absorb its taste and odour, but this objectionable feature applies to other disinfectants of a different class. Alcohol has a marked deterrent effect on the germicidal action of phenol, and a solution of carbolic acid in alcohol owes its bactericidal power chiefly to the effect of the alcohol. Crude carbolic acid is, in general, unsuitable for disinfecting purposes owing to the fact that it is but poorly soluble in cold water.

Compound solutions of cresol are to be preferred to carbolic acid for ordinary disinfection, and, in general, a 2 to 3 per cent. solution will be of sufficient strength; soft water should be used when possible.

Carbolic Powders.—These consist of crude carbolic acid mixed with a variety of absorbent materials. Carbolic powders are almost inert if made with slaked lime, chalk or any alkali, as the resulting carbolate of lime has practically no disinfecting properties. The best substances to use are gypsum, infusiorial earth (such as Kieselguhr), bricks, peat, sawdust, and almost any cheap non-alkaline substance capable of absorbing the acid without combining with it may be used for the purpose. The proportion of carbolic acid should be at least 15 per cent., but Kieselguhr will absorb as much as 30 per cent. In general, carbolic powders should find no place among disinfectants, they merely delay decomposition. The sight of them scattered about and the smell they give off appeals

to people who do not understand the basic principles of cleansing and disinfection.

AERIAL DISINFECTION.

FUMIGATION.—Gaseous disinfection was at one time carried out to a very great extent, and much dependance was placed on the supposed power of the generated gases to destroy pathogenic organisms. It is now known that the utility of gaseous disinfection is very limited, and that the "disinfection," even under the most favourable circumstances, is mostly unsatisfactory. It may, however, sometimes be used as an adjunct to other measures with profit.

Fumigation has for its object the disinfection of the air in a room or building, and the penetration of the gas into every part. To be effective, the room or building must be rendered air-tight, otherwise constant dilution of the gases occurs. Even with the room of an ordinary dwelling-house it is extremely difficult to prevent this dilution. In stables and byres, &c., it is a physical impossibility. The only circumstance under which in veterinary practice it might be used are in suitably-constructed loose-boxes, and in dog kennels and catteries.

Fumigation of ships is also of benefit, but chiefly for the lethal effect of the gas on vermin which might be disease carriers.

Three gaseous disinfectants are used — sulphurous acid gas, chlorine gas, and formic aldehyde.

SULPHUROUS ACID GAS. *Sulphur Dioxide.*—This is generated by burning flowers of sulphur or sulphur in the stick form in a room, the atmosphere of which is moist. In order to be effective 3 pounds of sulphur should be burned for each 1000 cubic feet of space. It is of the greatest importance that the atmosphere be moist, the combustion of sulphur in a dry atmosphere is useless so far as any germicidal action is concerned. The SO_2 produced by the combustion of the sulphur unites with the oxygen in the building to form SO_3, and this combines with the moisture in the air to form H_2SO_4. Hence the necessity of the air being made moist before combustion is started. In loose-boxes, stables, &c., this is easily done by washing down the stalls, walls, &c., with the hose pipe. Three pounds of sulphur per 1000 cubic feet will yield 3 per cent. of the gas in the building.

The sulphur should be placed in a tin, and if sticks are used they should be broken in pieces to facilitate combustion, a little alcohol added, and then ignited. Specially prepared candles are more

convenient than the crude sulphur, as combustion is more certain and more complete. Sulphurous acid gas is also liquefied and stored under pressure in cylinders.

SO_2 is a heavy gas and does not diffuse well; though it is the usual custom to place the sulphur on the floor for combustion, better results are possibly obtained when the holder containing the sulphur is suspended near the ceiling or roof.

Foodstuffs such as hay, oats, &c., very readily take on the disagreeable odour of the gas.

Chlorine Gas. — Chlorine gas is generated from bleaching powder by causing a mineral acid, such as sulphuric acid, to slowly drip on to it. The reaction is as follows :—

$$CaOCl_2 + H_2SO_4 = CaSO_4 + Cl_2 + H_2O$$

The chlorine gas unites with the hydrogen of water and liberates nascent oxygen.

As with sulphur dioxide, chlorine gas is practically useless in a dry atmosphere. The same quantity of bleaching powder is required as in the case of sulphur, namely, 3 pounds per 1000 cubic feet, but from 1 to 2 per cent. of the gas in the air is considered sufficiently powerful to destroy non-sporulating bacteria. The exposure should not be less than three hours, and a longer time is desirable. To acidify 2 lbs. of bleaching powder approximately 1 lb. of acid is required. Chlorine is little used now for aerial disinfection.

Formaldehyde Gas.—The chief use of formaldehyde is in the vapour form. When formalin is evaporated in the air, the gas formic aldehyde is liberated but in a dry atmosphere polymerisation to paraformaldehyde soon takes place as before stated. Therefore for the gas to have any potency the atmosphere must be moist, and the best results are obtained when the gas is generated along with vaporisation of water from a special lamp. The gas formed combines with the vapour so that disinfection by formaldehyde gas is rather a vapour action than a gaseous one. The object is to produce a fine mist that will fall evenly throughout the room. It is thus seen that with vapour disinfection the surface of things exposed to the film are the only parts affected. It is an air disinfectant of some value and may be used in the disinfection of the air in kennels and catteries following an outbreak of distemper and influenza. There are several forms of vaporisors on the market, directions for use being given with each.

The Potassium Permanganate Method.—With this method the 40 per cent. commercial formaldehyde is poured on to crystals of potassium permanganate; powdered permanganate is said to be

useless. A chemical reaction takes place with the generation of heat and the liberation of formaldehyde gas. The amount of gas formed, and consequently the efficiency of the method, depends very greatly on the relative proportions of the solution of formaldehyde and the permanganate. The best results are obtained with six parts by weight of the 40 per cent. solution to five parts of the crystals (Dorset). A considerable amount of the formaldehyde is in any case destroyed, but if this proportion is used about 50 per cent. of the formaldehyde is converted into gas available for effective action. For disinfecting 1000 cubic feet of space 20 ounces of formaldehyde and $16\frac{2}{3}$ ounces of permanganate are required.

The permanganate should be placed in a bucket on the stable floor, or, if there is a wood floor placed on bricks, the solution poured on and the room closed and sealed. Twelve hours should be allowed to elapse before the gas is allowed to escape.

To get rid of the irritating vapour after disinfection is completed blow ammonia through the keyhole, this forms on combination with the formaldehyde hexamethylenetetramine.

Standardisation of Disinfectants.—With the large number of disinfectants now on the market it is very desirable to know their relative germicidal action. This is especially necessary with the tar preparations, the composition of which are so variable. The germicidal action of pure carbolic acid or phenol has been carefully determined under conditions of temperature, period of exposure, nature of the medium containing the bacteria, &c.

It is therefore taken as the unit of comparison, and other disinfectants are tested under identical standardised conditions so that their relative strengths compared with carbolic acid may be determined. Thus if a given strength of carbolic acid, say a 1 per cent. in distilled water, be taken as 1, then other disinfectants of a 1 per cent. strength will be either greater or less than 1 according to their potency.

The bactericidal potency of disinfectants is affected greatly by the presence or absence of organic matter, so that the tests are made without organic matter and in a standard nutrient broth. The time of exposure, the bacteria to be destroyed, the temperature, the medium holding the bacteria, and the other conditions remain constant, and are standard conditions. The disinfectant to be tested is then used in various dilutions until it is found what dilution will destroy the bacteria in the same time as a given strength of phenol, and under the same standard conditions. Suppose it is found a certain disinfectant in a solution of 1-1000 will do the same work

in the same time as a 1-100 solution of phenol, then 1000/100 is 10; 10 therefore is the "carbolic acid coefficient" of the disinfectant. This is known as the Rideal-Walker method of standardising disinfectants.

This method of testing disinfectants is most suitable for chemicals of the same class, such as those of coal-tar origin.

DISINFECTION OF STABLES, COW BYRES, PIGGERIES, &c.

With all disinfecting operations the *modus operandi* depends upon the nature of the infective agent that has been at work. The hygienist will naturally bring thought to bear upon the disease he is combating, and will suit his tactics to the individual case. Hereunder are given the chief points to be considered with the more common zymotic diseases; exceptional conditions must be met as they arise.

Disinfection for Mange.—It is of course useless to disinfect a stall in which there still stands an infective animal, but it is likewise poor policy to keep an animal undergoing treatment in a stall or box that is presumably harbouring numbers of the parasites. The most satisfactory procedure to adopt is to remove the patient to a clean stall after he has been thoroughly dressed and to give him clean bedding on which to lie (the practice of keeping mange-infected horses without bedding is not to be recommended), and then to disinfect the vacated stall in the following manner. First remove all the bedding and scrape as much as possible of the dung and dirt from the floor. It is important to do this as soon as possible after the animal has left the stall as any parasites on the bedding may attempt to migrate to the adjoining stall in which there may be a clean animal. All this bedding and dirt should be placed in a heap and burned without delay. Since the majority of the parasites that have been left behind will be located on the floor, on the stall partitions, and on the under surface of the manger and hay rack it is to these that attention should be first given. Having removed as much of the dirt as possible by scraping the floor, the latter should be thoroughly soaked with a disinfectant, care being taken that it penetrates into all the corners and angles. A 2 to 5 per cent. solution of Jeyes Fluid is suitable for the purpose. A 2 per cent. solution of Liq. Cresol. Sap. or of carbolic acid is said to kill the mites in a few minutes, but it is advisable to use double this strength. Though mange parasites soon die and their eggs dry up in a *dry* atmosphere, it is probable that they will live for some weeks in damp and dirty stables with uneven floors. If the disinfectant

is left soaking on the ground for a day it is tolerably certain that all the parasites thereon will be killed. The treatment of the stalls must vary with their construction. If they are of well-finished hard wood, such as teak, all that is necessary is to scrub them thoroughly with a similar disinfectant to that advocated for use on the floor, particular care being taken that the solution penetrates into the crevices at the junction of the boards. If, on the contrary, the wood work is such as is commonly seen in farm stables and the like, namely, soft pine so worn by age that it is covered with cracks and crevices, then any amount of washing is not to be relied upon. Fortunately such wood can be treated with direct heat without doing it any damage, and undoubtedly the best method is to flame the whole surface with the painter's lamp. This is not necessary on good sound hard wood.

The stall partitions must be treated with the lamp over their entire surface, and the walls of boxes to a height of at least eight feet. The manger-troughs and hay rack require to be carefully cleaned, and if of wood should be flamed; it is of great importance to pay attention to the under surface of the racks and mangers as horses invariably rub their necks against such places. The average stable attendant is not to be trusted to do this satisfactorily, and the practitioner would be well advised to witness this part of the disinfection himself. It is the most important part of the proceedings and the one most neglected. The doors and door jambs also call for special attention. So far as is possible, taking into consideration other inmates in the building, all doors and windows should be left open so as to let in as much light and air as possible.

When the stable is thoroughly clean and dry there is no need to do more to it, and horses may be admitted into the once contaminated stalls without fear of infection if the work has been properly done. It is, however, the common practice to whitewash the stable throughout after disinfection. It should be remembered that whitewashing in itself is not to be depended upon for disinfection, and should not take the place of the measures above recommended. Whitewashing is, of course, out of the question in expensively built stables with polished hard wood fittings and is also quite unnecessary, but with many farm stables and the cheaper class of buildings found in towns it serves a useful purpose by making the place lighter and giving it a fresher appearance. The methods of making and applying limewash are discussed on page 210.

Strangles. — Disinfection of stables following an outbreak of strangles is to be done on much the same lines as

advocated for mange; a preliminary cleansing followed by true disinfection.

Particular care is to be taken to see that all the bedding and soiled food is destroyed. The water pot, or bucket, the hay rack, manger, &c., call for special attention, scalding and scrubbing with hot soda solution being a most useful procedure.

The great point to remember is to make the place clean, and this is the most difficult thing to get done.

Influenza and Pneumonia. — With such diseases as these, in addition to the general measures it is advisable to disinfect the roof and air of the building. This may be done by generating sulphur dioxide or chlorine gas as described on page 215. It is important to bear in mind that such disinfection, or rather attempted disinfection, is of no avail if the atmosphere in the building is dry. A sufficiency of gas must be generated, 3 lbs. of sulphur being required for each 1000 cubic feet of air space. The place must be completely sealed for twenty-four hours. Too much reliance should not be placed on aerial disinfection, and in many stables it is impossible to carry it out owing to the structure of the roof. A thorough washing of the walls and as much of the roof as can be done by means of the hose pipe is to be recommended and lime-washing, the wash containing 5 per cent. of carbolic acid, with a spray pump is advantageous. Aerial disinfection can then be done as an aid to the other more useful measures.

The casual burning of a few sticks of sulphur in a loose-box while it may appeal to the layman does very little good.

The author has adopted the following method as a routine hospital practice for the disinfection of hospital boxes. The boxes, which are faced throughout with smooth cement, are flushed out with plenty of water and scrubbed with brushes; when the place is clean, the walls, floor, door, manger, &c., are scrubbed with a solution of bleaching powder, 1 lb. to a stable bucket of warm water, the doors and windows are then closed for twenty-four hours, after which the place is opened up and again scrubbed out with plenty of water and then left to dry. The bleaching powder leaves the place clean and fresh, and in the case of mange-boxes removes the grease from the walls.

Disinfection of Piggeries.—A piggery may require disinfection following an outbreak of swine fever, swine erysipelas, anthrax, parasitic bronchitis, or other infectious malady such as tuberculosis. When anthrax occurs in a piggery it must be dealt with along the lines indicated on page 223. To what there has been said it is only necessary to add that the source of an outbreak of

anthrax in a piggery is more easily traced than is the case when the disease affects cattle.

Feeding butchers' offal is the most common method by which the disease is introduced, and therefore special attention needs to be paid to offal containers, carts and feeding utensils.

In one outbreak with which the author came in contact the use of bedding from a farm where an anthrax carcase had been skinned was the cause of the trouble.

In the case of *swine fever* the disinfection is under the control of the lay inspectors of the Ministry of Agriculture, the veterinary inspector has nothing to do with it. It is, nevertheless, quite conceivable that the modern enlightened pig owner may desire a more expert opinion than it may be presumed the uninitiated lay inspector is able to give.

From one's knowledge of swine fever, and the means by which it is spread, it is clear that the cleansing and disinfection should be specially directed to those parts of the premises and to such things as are most likely to have been in contact with the pigs themselves or their excreta. These include the floor, lower parts of the walls, food-troughs, pig crates, nets, brushes and shovels, &c., used in cleaning out the pens, the boots of the attendants and any other things that the practitioner thinks may have been in contact directly or indirectly with infective material. It is generally considered that infective manure loses its virulence in a comparatively short time, so that it need not be destroyed or treated in any way with chemicals, but infective manure taken from the piggery should be buried among the hot manure in the pit.

The average pig-keeper when he gets an outbreak of disease among his animals immediately proceeds to whitewash anything and everything. The most difficult thing to get him to do is to clean the place first. Cleansing must precede disinfection in this case. The pens should be well scraped out and the scrapings added to the dung heap.

Water should then be freely used, and the place be thoroughly scrubbed out. The food-troughs should be well scrubbed and scoured, and, if of the removable type, be taken outside and exposed to the air and sunlight. If there is a bed-platform of wood, this should be treated in the same way; it need not be destroyed. All the corners and angles in the pens and passages should be picked out clean. The walls require scrubbing to a height of at least six feet, but, if the piggery is particularly dirty and ill-lit, the cleansing operations may well be extended to other parts that are not necessarily splashed with manure. An outbreak of disease is

often the only opportunity there is to get a place clean; it is well then to make the most of it. Following the preliminary cleansing the premises and equipment may be disinfected. For this purpose there is nothing to equal "chloride of lime" (bleaching powder).

The floor, walls, food-troughs, bed-platforms, &c., should be scrubbed with a solution of not less than 10 per cent. strength (made with fresh bleaching powder) and then be left for twenty-four hours, after which the entire place should be thoroughly scrubbed out to get rid of all residue. The doors and windows must then be left open to get the place dry, after which fresh animals may be admitted with safety. If, however, the cleansing and disinfection has been improperly carried out or not supervised by a properly trained person, it would be unsafe to admit pigs to the premises for a fortnight or three weeks.

The careless use of disinfectants about animal houses must be guarded against. The author had to deal with an outbreak of swine fever in a particularly foul establishment, and found that the owner had spread "chloride of lime" over the yard to which his fowls had access. The birds drank from the pools of water (or rather liquid filth) into which the powder had been thrown and more than half his stock died.

Swine Erysipelas.—One is generally led to believe that this disease thrives only under filthy conditions. This may in part be true, but repeatedly it is encountered in piggeries where no trouble is spared to keep the place clean. In the present state of our knowledge concerning the disease we should make every endeavour to cleanse and disinfect the piggery once the disease appears. The procedure should be the same as that advocated for swine fever, again paying particular attention to the floor. If there are stagnant pools of dirty water in any part of the yard to which the animals may get access, or through which attendants may walk, these should be filled up and better drainage arranged for. If the piggery is dark and damp, then light and air must be admitted. If the floor is uneven and pitted with holes it should be relaid or levelled and washed over with cement. Corners and angles should be filled in with a fillet of cement. As with many other diseases it is probably more a question of cleanliness than of disinfection.

The actual disinfection of the floor, troughs, &c., may be done with a solution of bleaching powder, as described above, or by watering freely with one part of strong commercial sulphuric acid to three of water. The usual care must be taken to see that all crevices and interstices between the bricks of the floor are well

filled with the disinfectant. The disinfectant should be left for a day and then be washed out and the place dried.

Disinfection following Anthrax.—Of all the diseases with which the veterinary practitioner has to deal, anthrax is the one that causes him the most thought and worry when he has to consider what steps he should take to prevent other cases from occurring.

Not only has he to remember that disinfection carelessly done may mean a reappearance of the disease and possible loss of human life, but he has always to keep in mind that the carrying out of the disinfection itself is not free from danger to those engaged in it. A farm labourer engaged in the removal of soiled bedding or unfastening the halter from the head of a cow that has died of anthrax may readily get some of the anthrax blood on his hands or clothes. The slightest abrasion of the skin affords an entrance to the bacilli; an itchy pimple on the neck scratched by the fingers that have come in contact with the infective blood has on more than one occasion been the cause of anthrax in man. It is therefore of the very greatest importance that every possible precaution be taken to prevent persons from touching any part of the carcase or anything that might be infective.

The way in which an anthrax carcase should be disposed of is explained under the headings dealing with Anthrax and Disposal of Carcases ; here we are only concerned with the disinfection of the premises and utensils. For this purpose the case of a cow that has been found dead in a double stall in a byre of the ordinary commercial type may serve as an example.

It sometimes happens that for a brief period preceding death, and for some time after, the afflicted animal will discharge quite an appreciable quantity of blood from the nose and anus. The blood from the nose may contaminate the food-trough and perhaps the trough of the companion cow, and even be smeared on to the skin of the adjacent animal, which must therefore be treated as a suspect and be strictly isolated.

The natural and proper course is to remove her as soon as possible, and the practitioner will usually find that this has been done by the farmer. The entire double stall and the part of the dung channel below the stall must be considered as contaminated. The double stalls on each side of the infected one must be treated as in contact, and if possible be vacated of their animals and disinfected. It is tolerably certain that if the dead animal has been lying for any length of time in the stall that some infective blood-containing fæces will be found in the dung channel. As there is

always a slight flow of liquid in the channel towards the exit, steps should be taken as soon as possible to remove this dangerous material and to prevent its further spread. The whole of the contents of the channel (within the limits defined above) should be carefully collected with a shovel and taken for destruction in a receptacle that will not leak and that can be readily disinfected, but before its removal is begun all the liquid in the channel should be soaked up with any absorbent that is handy; earth is as good as anything else for the purpose.

Before any attempt is made to remove the soiled bedding and food from the stall the whole should be thoroughly covered with a suitable disinfectant, of which the dung channel must receive a liberal amount. Were it not for the possibility of tainting the milk collected in the byre, a strong solution of chloride of lime is much to be preferred to liquid disinfectants.

If a liquid disinfectant is chosen, then preference should be given to one that will mix well with water. Crude carbolic acid is unsuitable for this purpose as, under ordinary conditions, it does not mix with water satisfactorily, so that when the liquid is poured into the channel or on to the stall, &c., there is no certainty that the disinfectant will be brought in contact with all the infective material. The stall, once it and its fittings have been well covered with the disinfectant, should be left for a day and then the soiled litter and dirt may be removed and burnt. It is an unwise thing to start removing highly infective litter without taking any measure to disinfect it. If men commence their cleansing operations by walking about the stall before the floor and bedding have been treated there is a grave risk of virulent material getting on their boots and being carried to other stalls. When the bedding and dirt have been removed the whole of the stall and fittings may then be scrubbed down with scalding water and not less than 5 per cent. of a phenol or cresyl disinfectant. The following day the stall partitions and facing wall should be limewashed, the wash to be made with fresh unslaked lime and to contain not less than 5 per cent. of a suitable disinfectant.

If the floor of the stall is made of loosely-laid cobble stones or flagstones, they should be removed together with the first few inches of soil. If there are visible patches of blood on the floor, dung channel or fittings it is a good plan to well burn them with a painter's lamp. The tools used in removing the litter, &c., should be well flamed and all halters, sacks, rugs, &c., that have been in contact with the affected animal should be burned.

Disinfection of Harness.—The method adopted for the dis-

infection of harness naturally depends upon the nature of the contamination to which it has been subjected. Suppose, for example, during the conveyance of an anthrax carcase from a byre to the place of cremation some of the infective blood became smeared on the traces, which might easily happen if due care were not taken, it is quite unnecessary to disinfect the entire harness or to remove the padding of the saddle and collar which is such an important procedure when mange is the disease to be dealt with. All that is required is to disinfect the contaminated area, allowing a boundary for safety, or at the most to disinfect the entire harness without removing the padding. Each case must be treated on its own merits.

In the case of mange the greatest care must be taken to cleanse and disinfect every part of the gear, whether it comes in direct contact with the animal or not. The first thing to do is to take the whole harness apart, every buckle must be undone and all straps removed from keepers, &c. Fortunately there is no danger to human life in handling such soiled material as there is in the case of a blood-smeared trace or coupling.

The entire padding, if cloth-covered, should be ripped out from the collar and saddle; it is false economy to leave it alone and trust to luck in the disinfection. The additional expense is nothing compared with what it would be if the disinfection is incomplete and the disease breaks out once more. If the padding is leather-covered and the leather is in good condition it may safely be left, but if it is frayed and worn into holes it should be treated in the same way as the cloth covering.

Having undone all the harness the next thing is to free it from all grease and dirt. This is most important, for the disinfectant cannot act properly if there is a layer of dirty grease covering such parts as come in contact with the body. To this end scrub all the leather work with a hot solution of soda and soap, working the hairs of the brush well into and between seams and keepers. After this preliminary cleansing disinfection may proceed. An important thing to bear in mind is not to use chemicals that will spoil the leather or erode the metal work. Corrosive sublimate is unsuitable as it will tarnish or even pit the metal. The same objection applies, though in less degree, to the use of a solution of bleaching powder. Formalin is said to make the leather hard and brittle. A 5 per cent. solution of carbolic acid, or a 3 per cent. solution of Liq. Cresol. Sap. or Jeyes Fluid in suitable strength are all excellent for the purpose.

The harness should be soaked for an hour or two in the solution

and then well scrubbed with it. It should then be rinsed in clean water and hung up to dry out of the sun. When dry a good rubbing with harness composition or with soft soap will prevent it from becoming brittle. Re-padding may then be done.

Disinfection of Drains.—Some disinfectants and so-called disinfectants on the market bear on their labels directions to pour so much of the particular fluid into the drains for disinfection or deodorant purposes. This procedure is, of course, of benefit to the producer since it disposes of more of the material than would be effected by more useful methods. Here the utility of the practice ends. In the first place no drains under normal circumstances should need disinfecting or deodorising, if they smell they are faulty and need reconstructing.

So far as the actual disinfection of drains is concerned this is very seldom necessary, and is indeed practically impossible to carry out satisfactorily. In veterinary practice only the spores of anthrax require consideration, and it is due to carelessness or ignorance that these gain access to a drain.

The *B. anthracis* is a dangerous organism to be present in any system of drainage. If in a public system it may reach a sewage farm and cause the disease among cattle fed off the produce gathered from the farm. Such instances must, however, be very rare. In any case the disinfection of a drainage system presents many difficulties. Pouring liquid disinfectant down the drains as is so commonly done is quite useless owing to the great dilution to which the fluid is immediately subjected, and because it so rapidly passes away. Should it become necessary to disinfect a system, then the outlets of the various sections must be carefully plugged, the drains and pipes filled to their utmost capacity with the selected disinfectant, which must be left *in situ* for a sufficient length of time. Sulphate of iron is recommended, 1 lb. to each gallon of fluid.

The ordinary gully traps used in stable yards very often become evil-smelling; in nearly every case this is due to imperfect and infrequent flushing. A few spoonfuls of disinfectant will not cure the evil, but a weekly cleansing of the container bucket and a thorough flushing with water may be depended upon to ensure that no smell will be noticed, provided that otherwise the system is sound. Strong-smelling " disinfectants " (such as coal-tar products) act as deodorants by masking evil smells, but they usually fail to destroy the aerogenic organisms. The danger of using " deodorant disinfectants " is for this reason very real.

Disinfection of Cattle and Horse Trucks.—The cleansing

and at least partial disinfection of horse and cattle trucks after each time they have been used is compulsory under the Order of the Ministry of Agriculture and Fisheries (see Sanitary Law).

Such cleansing and disinfection is limited to the removal of excreta and soiled food, washing and subsequent whitewashing of certain specified parts. As a routine measure for keeping the trucks clean it is all that is required, but there may on occasion be instances where more vigorous means must be adopted, as for instance following the carriage of animals affected, or suspected to be affected, with foot-and-mouth disease, anthrax or other dangerous specific disease. Each case must of necessity be treated according to its particular requirements.

The most satisfactory way of cleansing a cattle truck or horse box is to remove all the dirt and then forcibly spray the whole inner surface of box, gangway, &c., with a 5 per cent. carbolic solution; subsequently the box may be scrubbed out and when dry be limewashed, the wash to contain 5 per cent. of carbolic acid. Fumigation is impossible owing to the open nature of the trucks and the impossibility of making them gas tight.

DISPOSAL OF CARCASES.

The carcases of animals may be disposed of by sending them to a knackery or to a destructor, or by burial or cremation.

In the case of cattle, a Local Authority may require notification of any death from illness, except where such death results from accident or calving, and stipulate that no head of cattle (bulls, cows, oxen, heifers, and calves) which has died or been slaughtered on account of illness may be removed or destroyed until it has been inspected by a Veterinary Inspector of the Local Authority, or a certificate has been granted by a veterinary surgeon that death has not been due to any of the "scheduled diseases." Animals which have died or have been killed on account of having been affected with a "scheduled" disease, or suspected of having been so affected, are disposed of under the regulations of the Ministry of Agriculture and Fisheries.

The safest and most expeditious way of disposing of dangerous carcases, such as those of animals that have died of anthrax, is to have them destroyed in a digester or destructor, and the procedure adopted by the Lanark County Council is undoubtedly the ideal one. This progressive county has a contract with a knackery for the removal of anthrax carcases in a specially constructed cart, and for their destruction.

This procedure is expeditious and safe, and saves a lot of trouble and anxiety. It is a method which should be adopted by every Local Authority.

Failing chemical digestion or destruction by heat or steam in a destructor, the carcases must be burned or buried. The pros and cons for burial or cremation of anthrax carcases, and the method of conveying them to the crematorium or site of burial have been discussed under the heading dealing with Anthrax (see Anthrax and Disinfection).

Cremation of Carcases.—There are two accepted methods for the cremation of carcases in the field. One recommended by General Sir F. Smith and the other advised by the Ministry of Agriculture and Fisheries. General Smith's method is as follows* :—

Dig a trench in the ground in the shape of a cross, each trench to be 7 feet long, about 15 inches wide, and 18 inches deep at the centre where the two meet, and becoming shallower as they rise to the surface of the ground. Throw the earth into the angles formed by the trench and on this place two stout pieces of iron. The trench provides the draught. Use a layer of stout wood to make a base, and on this place the carcase followed by more wood. The pile is lighted by straw.

The method of cremating anthrax carcases recommended by the Ministry of Agriculture in a Memorandum to Local Authorities, known as the Bostock Method, is as follows :—

Dig an oval pit 7 feet long, 4 feet wide, and 3 feet deep, with a cross trench at the bottom 9 inches wide and 9 inches deep. Dig a trench 4 feet long, 18 inches wide and 4 feet deep, about 1 foot from and at right angles to one of the long sides of the pit, and connect this trench by a tunnel with the cross trench in the pit. In loose soil the tunnel may be made with a drain pipe. If the pit is dug on level ground, this trench should be dug 4 feet 6 inches deep to allow of drainage from the cross trenches, which should in that case slope with the tunnel into the trench. This trench is for draught and drainage, and should be on the lower side of the pit. Lay one-third of the fuel in the pit, some wood being arranged over the cross trenches to keep them clear. Sprinkle with paraffin oil. Place the carcase into the pit and arrange the remaining two-thirds of the fuel round and over it. Light the fire at the draught tunnel. When well alight, the fire usually requires no attention, and stirring it would only waste the fuel. The fuel required for the carcase of a large bullock is about ½ ton of coal,

* *Veterinary Hygiene,* 3rd. Ed., 1905, p. 412.

½ ton of wood, 56 lbs. of straw, and 2 gallons of paraffin. Coke and peat may be substituted if more easily obtainable. The Ministry states that the advantages claimed for this method of cremation are :—(1) Economy of fuel; (2) No machinery or gird; (3) The pit, being shallow, can usually be dug in the most convenient place for the cremation; (4) The fire, when once alight, requires no attention; (5) Complete combustion is secured with the least possible quantity of fuel, the carcase itself feeding the fire and the heat being concentrated in the pit, instead of being wasted in the open air; (6) By means of the intense heat generated in the pit, smell from the burning carcase is avoided.

Veterinary surgeons who have had experience of this method

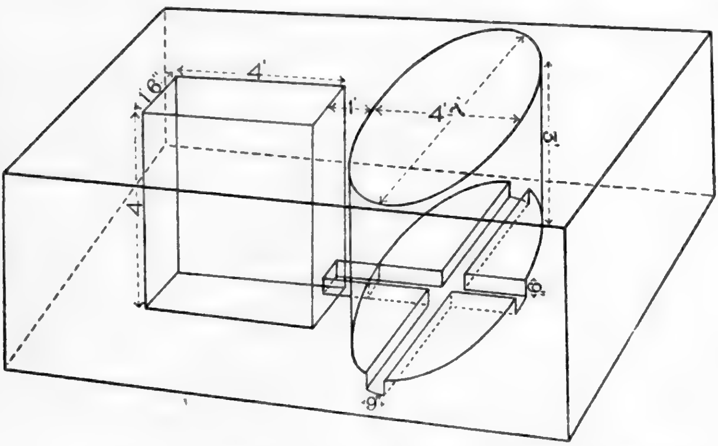

Fig. 92.—Diagram showing the dimensions of the Bostock Pit for the cremation of cattle.

of cremation will know that the claims are not exaggerated, and to these may be added that it is much easier to draw a carcase into this pit than it is to drag it up and on to an elevated pile.

Burial of Carcases.—When carcases of "diseased" animals are buried they must be placed at such a depth that there is six clear feet above them, and they must be covered with a sufficiency of quicklime or other disinfectant. Animals which have been buried may not be dug up without permission from the Ministry of Agriculture.

It is often impossible to dig a pit to the required depth owing to underlying rock. The site chosen for burial should be such that there is no possibility of contamination of the water supply.

It is an offence to throw into the sea within the three-mile limit or into any river, stream, canal, navigation or other water the carcase of any animal which has died of disease or has been

slaughtered as diseased, or suspected of being diseased (Diseases Animals Act, 1894, sec. 52).

TUBERCULOSIS.

Tuberculosis is a contagious disease of man and animals due to the *Bacillus of tuberculosis* or *Bacillus of Koch.* The latter discovered the micro-organism in 1882, but the transmissible nature of the disease had been proved by Villemin in 1865.

The disease has been known in Great Britain and most parts of the world from a very early date, and at the present time is one of the most wide-spread of animal plagues. M'Fadyean has estimated that in Great Britain between 30 and 40 per cent. of cattle are affected, but its widespread nature was not entirely realised until the discovery of tuberculin.

Three principle types of tubercle bacilli exist in nature, namely, the so-called bovine, human, and avian types, these differing from one another in pathogenicity and method of growth in artificial culture media.

From the point of view of the hygienist it is essential to notice :—

(*a*) That cattle are subject to infection naturally with the bovine type.

(*b*) That man may be affected by either human or bovine bacilli.

(*c*) That swine are most commonly infected by bovine tubercle bacilli.

(*d*) Of other animals, the horse as a rule shows infection with the bovine type, but commonly also with bacilli which do not strictly belong to either type.

(*e*) The dog and cat may show infection with either of the mammalian types.

(*f*) That farmyard poultry are liable to infection with the avian type.

No animal is immune to inoculation with one or more of the three principal types of tubercle bacilli.

The tubercle bacillus is a strictly obligatory parasite. The average temperature in this country is too low to permit of its multiplication outside the body. Even in tropical countries where the temperature is sufficiently high, it certainly does not multiply, since it is difficult to induce it to grow on artificial media, even when these are specially selected.

The disease is in the majority of cases of a chronic nature and as a rule slowly progressive. Contact between healthy and diseased

animals for a brief period does not necessarily imply that the former will become infected, but if the period of cohabitation is extended infection is almost certain to be transmitted if the environment is suitable. Tuberculosis is, therefore, a very insidious disease and one of very grave importance to the hygienist.

Among the different species of animals cattle are of course most frequently infected, while cases are occasionally observed in equines, and one or two instances of natural infection have been recorded in the sheep by M'Fadyean and others. The disease is not by any means rare in the dog and cat and occasionally outbreaks are seen amongst poultry. The disease is rare in goats. Tuberculosis does not occur among wild animals in a state of nature, but many species, and especially monkeys, suffer from the disease when kept in confinement.

Tuberculosis is universally but unequally distributed among cattle, and the percentage of affected animals tends to rise in proportion as the size of the herds increases. More cases are observed in Shorthorns and Ayrshires than in any other breed. Jersey cattle and Herefords, and especially the former, are particularly free. The disease is also infrequently observed among Scottish Highland and Welsh cattle. Pedigree strains are more susceptible than common bred animals, also the incidence of the disease according to age depends entirely upon the conditions in which the animals are kept. It is not often seen in yearlings, and is rare in calves. It is most frequent among adult cattle and especially amongst old cows which for long periods have been stalled in close contact. It is important to note, therefore, that the incidence of tuberculosis does not run parallel with susceptibility according to age; thus, though calves are almost entirely free from the disease naturally, they are more susceptible than adults to experimental infection.

No statistics of any definite value are available to show the distribution of tuberculosis in the United Kingdom, but the following figures calculated on fourteen months' working of the Tuberculosis Order give at least a relative idea of its incidence in the different parts of the kingdom. During the period 1st May, 1913 to 30th June, 1914, in Great Britain there were 7952 cattle destroyed as being affected with either tuberculosis of the udder or tuberculosis with emaciation. This represents 6816 cattle for a twelve months' period, which were distributed as follows :—

England	441	per month	at the rate of	5292	per annum
Scotland	102	,,	,,	1224	,,
Wales	25	,,	,,	300	,,

The number of cows and heifers in calf or in milk in June, 1914,

taken from the official returns, together with the calculated annual loss, and this loss expressed in units per 100,000 is given in the following table :—

	Cows and Heifers.	Loss per annum.	Loss per 100,000.
England	2,184,615	5,292	242.2
Scotland	453,703	1,224	269.8
Wales	299,605	300	100.1
Ireland	1,638,929	1,406	85.7

Such figures do not afford any true indication of the prevalence of the disease in this country, but merely represents what is probably but a rough estimate of the cows and heifers affected with the tuberculosis of certain types, and that only for the period given.

Tuberculosis is more prevalent in city byres than in country ones, this being partly attributable to the fact that practically none of the former are self-contained but are continuously changing their stock, and must perforce buy in the open market without any guarantee of freedom from infection.

It follows from what has been said before that housed cattle are more commonly affected and, according to Hutyra and Marek, the disease is practically unknown on the prairies of North America and on the steppes of Eastern Europe. According to some writers, however, the disease is met with even among cattle which spend the greater part of their lives in the open air. For instance, Russell* states that he has noted several instances in which range cattle which had never been housed were found to be badly affected. Bang, in his report to the Seventh International Veterinary Congress, states that " it is certain that often in the open air infection is not excluded, especially when the cattle are free to run about and lick one another, and when several animals are allowed to drink from the same vessel."

The period of incubation for tuberculosis is usually prolonged, but it is variable and uncertain. Months or years may pass before an affected animal shows clinical symptoms of the disease.

The organism remains virulent outside the body for a considerable period if in a suitable environment. Its resistance in the face of different agencies is shown by the following examples† :—Cadeac and Malet found tubercle bacilli to be still alive and virulent in putrefied cattle lung after 167 days. Schill and Fischer noted dry sputum protected from light to be virulent for 126 days. Desiccation *per se* is therefore not a destructive agency.

* *Bovine Tuberculosis*, Devine, Chicago, 1917, p. 15.

† Hutyra and Marek, *Spec. Path.*, Vol. I., p. 507, Trans.

In raw milk they were found to be alive (Gasperini) for 10 days, at the end of which they were probably destroyed by lactic acid. Harrison found them to be virulent for 104 days in Cheddar cheese. They resist freezing, but, on the other hand, direct sunlight destroys them in a few hours.

Traum* has recently shown that tubercle bacilli in fæces and lung discharges are no longer viable (as shown by the inoculation test) after exposure for 3 months in a dry season but that they can remain alive for at least 6 months in water.

The vitality of the organism in the face of moist heat is of the greatest importance owing to the frequent contamination of milk. Bang† in his first experiments found 85° C the minimum temperature to which milk should be heated with the object of destroying the organism. Later he repeated his experiments and found that 70° C for one to two minutes is sufficient, though he was careful to advise in practice the heating should be continued at 85° C. Delépine on the other hand found that tubercle bacilli in cream are capable of resisting a temperature of 85° C for 15 minutes and therefore advised that the milk should be boiled. The heating of milk, even to 85° C, has the effect of appreciably altering its flavour, and there appears to be no way of avoiding this. In the case of animals, however, this fact is of no moment, and consequently it is advisable to stipulate that the milk should be brought to boiling point and kept there for 10 minutes. To satisfactorily sterilize milk for use as human food, the best policy is to place the receptacle containing the milk within an outer vessel containing water and to continue the heating until the water has been at boiling point from 20 to 30 minutes.

Inhalation is the most common method by which cattle become infected, and the disease being strictly contagious the source of infection is always a previous case. One of the principal ways in which infection is distributed in a cow-shed is by means of the tubercle bacilli contained in the expired air of animals infected with pulmonary tuberculosis. In addition to this, tubercular disease of the lung produces in many cases a considerable amount of expectoration. A portion of this expectorate is discharged *via* the mouth and nose but the bulk of it is swallowed, and the bacilli are thus voided in the fæces. The bacilli are also occasionally excreted with the urine and in those cases in which the uterus is the seat of disease in the vaginal discharge. Infection of healthy animals is

* *Journ. Amer. Vet. Med. Assoc.*, Vol. LII., No. 3, Dec., 1917, pp. 289-299, through *Vet. Rev.*, Vol. II., No. 2, May, 1918, p. 207.

† *Journ. Comp. Path.*, 1901, Vol. XIV., p. 233, Trans.

thus rendered easy in crowded, ill-ventilated byres not only by tubercle bacilli contained in moist particles in the expired air, but also, and possibly to a less extent, by the tubercle bacilli contained in contaminated fæces, discharge, &c., which has become dry and has subsequently been raised into the air by draughts. Contagion may also be conveyed from one adult animal to another through the medium of soiled water, food, or expectorate containing tubercle bacilli, and though ingestion at least for adult cows plays a minor part compared with inhalation, its possibility must not be lost sight of. The feeding of calves with raw milk, either whole or separated, obtained from badly tuberculous cows, some of which may be suffering from tuberculosis of the udder, is the most common method by which young stock become affected.

With regard to the escape of bacilli from the body, use has been made of the expressions "open" and "closed" tuberculosis. By "open" tuberculosis was meant cases in which the lesions were in direct communication with the exterior, and from which bacilli were being more or less continuously discharged. "Closed" lesions were those in which, owing to their nature, such escape was declared to be impossible. The use of such expressions is misleading because often no one can say at any given moment whether bacilli are being discharged or not. The fact is that every animal which reacts to tuberculin must be looked upon as capable of infecting; such animals may appear to be in a perfect state of health, and at the same time be discharging large numbers of bacilli in the fæces, &c. In any case, according to Schrœder* animals which have been infected for three years or more are, with rare exceptions, spreaders of the disease.

A certain amount of controversy has raged around the question as to the infectivity or otherwise of the milk of reacting cows, which are apparently healthy and whose udders appear normal on clinical examination. Many observers (Ostertag, Hessler, Schrœder, Cotton, and others) as the result of their experiments, concluded that such milk does not contain tubercle bacilli, and it is generally agreed that this is so. In Great Britain, under the present conditions of the disease, it would be impossible on the score of expense to insist that the only milk sold should be derived from non-reactors. There is always of course the risk that the disease process may extend to the udder tissue, but in face of the objection mentioned that risk has to be faced. The possibility still remains that milk which in the udder contains no tubercle bacilli may be contaminated with them during or after the process of milking.

* *Journ. Comp. Path.*, 1908, Vol. XXI., p. 1.

This, however, is preventable, and owners of animals should see that milkers are in the habit of cleaning the udders and washing their hands before milking.

Transmission by inoculation is very rare in animals, but cases have been recorded in which man has been inoculated by handling tubercular material. Tubercular mastitis may result from local inoculation of an udder abrasion, and, according to Bang, the bacilli may gain access to the udder *via* the teat canal and through the medium of soiled litter. These methods of infection of the udder are most probably very rare, infection usually occurring through extension of a lesion within the abdominal cavity. Tuberculosis of the udder in point of frequency depends upon whether it is the practice in any particular herd to keep cows which are obviously badly affected, since as a rule the udder becomes invaded at rather a late stage of the disease. On an average somewhere about 1 to 2 per cent. of tuberculous cows have udder lesions (M'Fadyean).

One very rare method of infection in cattle is *per vaginam,* tubercle bacilli being transferred in a mechanical way by the bull during coitus, and the bull may thus contract tuberculosis of the penis.

In advanced tuberculosis in pregnant cows, the uterus and placenta occasionally become involved and infection is thus passed from mother to fœtus. Tuberculosis of the uterus is, however, very rare, and it is only in cases of uterine tuberculosis that this method of infection occurs, and probably the number of calves infected before birth does not exceed ·2 to ·4 per cent. This fact has been elicited by the results of the tuberculin test in calves only a few days old, and by the large numbers of post-mortem examinations which have been made of calves not more than a few weeks old. Knudzen* in Denmark in 1898 in over 13,000 slaughtered calves found only ·38 per cent. cases of congenital tuberculosis.

Prevention and Eradication.—The prevention of the spread of tuberculosis among cattle is of the very highest importance owing to :—

(1) The loss of life which occurs annually among the infantile population.
(2) The huge financial loss accruing to stock owners.
(3) The fact that the disease among other domesticated animals owes its origin in most instances to bovine infection.

The inherent difficulties in eradication are (1) its very great prevalence; (2) the slight economic loss which the disease inflicts upon individual owners. At the outset it is to be pointed out that

* *Journ. Comp. Path.*, 1899, Vol. XII., p. 189, quoted by Bang.

in Great Britain it would be entirely impossible to consider the eradication of the disease by means of the slaughter of the clinically-affected animals and all reactors to tuberculin. Such measures were tried in Belgium in 1895, but after two years were found to be impracticable. The authorities in Massachusetts made a similar attempt in the same year but the scheme had to be abandoned in twelve months.

Two chief methods of combating tuberculosis among cattle have been tried, namely, the method of Bang and the method of Ostertag, and of these the first has given excellent results in the countries in which it has been practised. Bang's method consists in principle of the slaughter of animals which are clinically affected, and of tuberculin testing and isolation of reactors and of the rearing of calves with milk which is free from tubercle bacilli. The herd is thus divided into two portions which are kept in separate premises in such a way that isolation is complete. Separate attendants are provided for the reactors and the non-reactors. The calves which are born of reactors are only permitted to suck their mothers during the first twenty-four hours; they are then added to the healthy portion of the herd and either provided with foster mothers or fed with milk which has been sterilized by heating to at least 85° C, unless such milk is known to be derived from healthy cows. The animals belonging to the healthy portion of the herd are submitted to the tuberculin test yearly, and any which react are added to the reacting portion. Reacting calves are usually slaughtered. Reacting animals are gradually disposed of by slaughter.

In spite of the difficulties, which consist of the trouble required to maintain efficient isolation, and the expense (which, however, need not be very great), Bang's method, if persevered with, is capable of transforming a tuberculous herd into an healthy one within a few years. The practicability of the method has been conclusively proved by the experience of Bang himself in Denmark, and more recently of Regner* in Sweden.

In Norway a more radical method of dealing with tuberculosis has been carried out since 1895. The cattle are tested and all reactors are slaughtered, no cattle being imported without being guaranteed free of infection and tested. Malm† states that this has been rendered possible by the small size of the herds (only a few containing as many as one hundred head) and by the fact that the majority of animals are kept in the open air. In 1897 there

* Hutyra and Marek, *Spec. Path.*, Vol. I., p. 595.

† Report to Tenth International Veterinary Congress.

were 8·3 per cent. reactors, and these had decreased to 4·8 per cent. in 1912.

As far as this country is concerned, M'Fadyean, in his report to the Tenth International Veterinary Congress, has very ably analysed the subject of the eradication of bovine tuberculosis and one cannot do better than quote *in extenso* from his report :—

" At least, as regards Great Britain, the two main reasons why the method of Bang has not been practised on a large scale are : (1) absence of incentive in the shape of expected return for the expense and trouble involved in eradicating the disease; and (2) lack of facilities for maintaining complete separation between the diseased and the healthy animals. . . . (1) because there is little or no demand for milk derived exclusively from non-tubercular cows; and (2) because the public have no trustworthy means of assuring themselves that the milk which purports to be from tubercle-free cows is really so. . . ."

" A survey of what has been accomplished up to the present time compels one to admit that no substantial progress towards the complete eradication of tuberculosis has been made. This failure is due to the inherent difficulties of the problem and to the fact that to most owners the prospects of ultimate gain do not appear to counterbalance the certain trouble and expense involved in an undertaking which is not even sure of success. In this connection it must be recognised that the conditions and circumstances are not identical in all countries. Factors of very great importance in determining the ease or difficulty of eradicating tuberculosis from any country are the average size of the herds, the individual value of the animals, the frequency of interchange of animals from one herd to another, and the proportion of herds still remaining free from the disease. To deal with the last point only, it would appear from the statistics published by Regner that at the beginning of the campaign against the disease in Sweden, out of a total of 1336 herds tested 534 (or 31 per cent.) were found to have no reactors in them. It is certain that in Great Britain the proportion of tubercle-free herds is far less than this, and among the principal milking breeds (Shorthorns, Ayrshire, and Jersey) it is doubtful whether it is as high as 5 per cent.

" The experience already gained, especially in Denmark and Sweden, indicates the great difficulty of freeing a herd from tuberculosis when the older animals are not tested at the outset, and also when, after such a preliminary test, the non-reacting old animals are regarded as certainly healthy and used as the nucleus for forming a healthy herd. In the former case there is the

constant danger that infection may spread indirectly from the old herd to the new one in process of formation if these are kept in adjacent buildings. In the second case the danger arises from the fact, of which there is plenty of evidence, that the ordinary subcutaneous test with tuberculin cannot be relied upon to provoke a distinct temperature reaction in every infected animal. This was one of the reasons assigned by Bang for abstaining from carrying out a preliminary test of the herd with a view to separating the infected from the non-infected. For reasons already stated it would in many English herds be hopeless to attempt to deal with the disease if all the animals already in the herd had to be left untested and regarded as diseased. It may, however, be asked whether the introduction of new methods of employing tuberculin has not in a large measure removed the objection to carrying out a preliminary test of the entire herd and accepting non-reaction as reliable evidence of freedom from tuberculosis. The writer's experience leads him to think that this question ought to have an affirmative answer. There is good reason to believe that by combining the ophthalmic and intradermic methods with the ordinary subcutaneous test the failures of tuberculin can be reduced nearly to the vanishing point. The combined method of testing marks a great advance, although none of the new methods used alone gives as low a proportion of errors as the original subcutaneous test."

In addition to the use of tuberculin, the isolation of reactors, &c., the following rules of hygiene must be carefully attended to. Byres must be properly constructed (see page 165); especially to be avoided is the system whereby stalls are arranged in rows so that the cows are facing one another. The exclusion of affected animals however, though infection is only revealed by a reaction of tuberculin, is the first consideration. Tuberculosis may spread under the best of hygienic conditions, but more quickly and more certainly in the foul byres too frequently seen in and about cities. The wall facing the cows, the partitions and feeding passage, if one exists, must be washed down at least once a week. The mangers must be cleaned out daily, a vigorous application of hose pipe and brush will rid a byre of enormous quantities of virulent material, which would, if left *in situ,* become partially dried and spread about the building, infecting all and sundry.

From the point of view of the spread of the disease to man, the most dangerous animal is the cow affected with tuberculosis of the udder. Milk from a tubercular udder always contains tubercle bacilli, and owing to the fact that the disease in the udder is always very slowly progressive, there is probably in every case

at the outset a period of weeks in which the lesion cannot be detected by clinical examination, and, furthermore, during this period there is no appreciable alteration in the character of the milk though this contains tubercle bacilli. The second most dangerous animal as regards human health is the milch cow affected with advanced tuberculosis of the lungs, firstly, because at any moment the disease may actually spread to the udder tissue, and secondly, because tubercle bacilli may be accidentally added to the milk through the medium of fæces which are likely to be heavily charged with bacilli. The Tuberculosis Order of 1913 has done a good deal to diminish the danger inasmuch as it requires compulsory notification and slaughter of cases of (1) tuberculosis of the udder; (2) tuberculosis with emaciation. Experience of one year's working of this Order has unfortunately shown, however, that probably 3 cases out of 4 of clinical tuberculosis have not been reported and this has probably been due for the most part to deliberate concealment of the disease by owners. The working of the Order would undoubtedly be made much more efficient if it insisted upon a periodical veterinary inspection of milch cows. Such inspections, which in most cases could not extend beyond clinical examination of herds, would unfortunately have to be rather frequent, with an inevitable rise in the price of milk. Veterinary inspections would have to be made at intervals of not less than a month, since it is well known that within a period of about three months a cow may pass from a state of apparent health to a dangerous state of the disease. In any case magistrates should be instructed to inflict very heavy penalties upon owners who have wilfully concealed cases of obviously advanced tuberculosis.

Bovine tuberculosis causes very appreciable losses among the infantile population of Great Britain, and in a large proportion of these cases infection is introduced through the medium of cows' milk containing tubercle bacilli. As would be supposed, it is especially young children which furnish the largest number of such cases. Thus Delépine in Manchester reported that between 1891 and 1900, of children under five years of age dying from tuberculosis in all forms to the number of 3930, 3517 were infected with tuberculosis other than phthisis. Furthermore, of 1936 cases occurring in persons from twenty to twenty-five years of age, only 206 were affected with tuberculosis other than phthisis. More recent reports* on this subject have been made to the Local Government Board by Eastwood and Griffith, who found that of 150 children dying from all causes between the ages of two and ten

* *Journ. Comp. Path.*, 1914, Vol. XXVII., p. 80, Abs.

years, 78 were affected with tuberculosis, 13 of these cases were due to bovine tubercle bacilli, and in 9 of them death was due to this cause. S. Griffith noted that in 7 out of 35 cases affecting children under twelve years of age bovine tubercle bacilli were present, and all of these were found in children under four years of age. Mitchell* in Edinburgh found that of 72 cases occurring in children under twelve years of age, 65 were due to bovine tubercle bacilli, and 36 of these occurred in children under five years of age. Finally, Eastwood and Griffith have examined a series of 155 patients under ten years of age suffering from bone and joint tuberculosis and isolated bacilli of the bovine type from 45, or 29 per cent. Further, of 17 cases of tuberculosis affecting the urino-genital system described by the same observers, bovine tubercle bacilli were isolated from three.

IMMUNITY.—Though actual recovery from tuberculosis is probably rare, a considerable degree of resistance is developed in animals during the course of an attack. Many different methods have been practised in the past with the object of producing immunity in healthy animals. The first and most important of these was that introduced by von Behring, which consisted of giving animals two intravenous injections of living human tubercle bacilli with an interval of three months between the two operations. The method was practised on a very large scale and a considerable degree of immunity was established in vaccinated animals, but unfortunately it was found that injected bacilli might remain latent in the animal's body for long periods. In the case of milch cows, they have been found to be excreted with the milk even though the vaccination was carried out soon after birth. This renders the method unsafe, and in the words of M'Fadyean " it may be questioned whether at least in the case of females the operation should not now be prohibited by law. Further, vaccination is a hindrance rather than a help when the object aimed at is the building up a tubercle-free herd. It is a hindrance because its employment is apt to draw attention away from the supreme importance of isolation as a safeguard against infection of healthy animals, and because it seriously interferes with the subsequent use of tuberculin in order to determine whether the vaccinated animals have remained free from infection with bovine bacilli or not." In experiments with calves, avian tubercle bacilli injected intravenously have also been shown to be capable of conferring a certain degree of immunity against subsequent test inoculations with bovine tubercle bacilli, but the method has not been put into practice on a very large scale and the pro-

* *Journ. Comp. Path.*, 1914, Vol. XXVII., p. 85, Abs.

tection afforded is certainly less than that produced by vaccination with human tubercle bacilli. Finally, according to Vallée* a vaccinated animal only offers a real resistance in proportion to the extent to which it remains a carrier of the vaccinating organisms.

TUBERCULOSIS IN SWINE.

The disease is of common occurrence among swine, and the Chief Veterinary Officer of the Board of Agriculture in his recent annual reports has drawn attention to its prevalence as found when examining pigs suspected of having swine fever (see Annual Reports for 1914, 1915, and 1916). Figures are quoted showing that in Glasgow and Birmingham 3·5 per cent. of all pigs slaughtered in these two cities were found to be affected with tuberculosis. It is certain that the disease is more extensive than these figures indicate, for instance, in 1914 the disease was diagnosed on 633 different premises and affected 989 pigs among 8632 kept, or 11·4 per cent. No reliable figures are available to show the extent of the disease within the United Kingdom.

Infection, though usually of bovine, is occasionally of avian origin, though the type of disease caused by the latter is not as a rule so severe as that produced by the former. The Royal Commission on tuberculosis also noted the presence of human tubercle bacilli in certain lesions from swine. Though unweaned pigs are at times found to become infected through the medium of the sow's tubercular udder, the disease is far more frequent among older pigs, and especially amongst those which are kept for breeding purposes.

Infection is chiefly derived from feeding on skimmed milk containing tubercle bacilli, slaughter-house offals, and from feeding from troughs which have previously been used by tuberculous cattle. Vallée and Villejean† have pointed out facts showing the frequency of infection in pigs fed with skimmed milk. In U.S.A., where pigs were fed exclusively on grain in 1894 to 1895, only ·0004 per cent. were tubercular, while in Denmark, where skimmed milk was used, some 15 per cent. were tubercular.

Tubercle bacilli are largely voided in fæces and the yards, pens, food-troughs and food thus become contaminated, and in this way infection may spread to other pigs.

Preventive Measures.—In the case of swine this should not be so difficult as with cattle. Tuberculin should be freely used on

* Report to Tenth International Veterinary Congress.

† *Journ. Comp. Path.*, 1904, Vol. XVII., p. 370, Trans.

all breeding stock when the disease has been found in the herd. Reactors should be slaughtered. The stock should be reduced as much as possible so as to leave a number of empty pens which can then be thoroughly cleansed and disinfected and used to hold fresh, clean animals. Only milk which has been previously well boiled, or at least heated to 85° C for a time, should be fed to pigs. Slaughter-house offals must be thoroughly cooked before being fed.

EQUINE TUBERCULOSIS.

The horse is not frequently affected with tuberculosis but it is not so uncommon as was at one time supposed. M'Fadyean* in 1888 described what he believed to be the first recorded case in Great Britain, though the disease had been previously encountered on the continent. Two cases only of natural tubercular infection in the horse due to the avian type have been described, the first in 1891 by Nocard, and the second recently (1918) by M'Fadyean. †

According to Wallis-Hoare and Lloyd the disease is less frequent among aged horses than among the young, and it is said to be less common amongst highly-bred animals than among cart-horses and harness horses.

Horses become affected from drinking milk from tubercular cows, as when they are hand-reared owing to the death of the dam. This is probably the chief source of infection, but it is also more than possible that broken fodder, water in troughs and ponds and the like, contaminated by diseased cattle may be the means of conveying the contagium by ingestion.

Preventive Measures.—If the foal has to be raised on cows' milk, this should be boiled. Possible infection from cattle can only be eliminated, of course, by eradicating the disease from the herd of cattle.

AVIAN TUBERCULOSIS.

Poultry keepers sometimes suffer heavy losses from avian tuberculosis. The disease runs rapidly through a poultry farm, the birds being ground feeders and the excrement of diseased subjects being extremely virulent. Poultry have also become infected by owners carelessly allowing them access to the carcases of diseased birds. Wild birds in captivity are also liable to suffer from avian tuberculosis, *e.g.*, parrots. Though the latter can be infected with avian

* *Journ. Comp. Path.*, 1888, Vol. I., p. 51.

† *Journ. Comp. Path.*, 1918, Vol. XXXI., p. 225.

tubercle bacilli, they are sometimes found to exhibit lesions due to human tubercle bacilli. One must, therefore, assume that such have been infected from phthisical persons. The possibility of such parrots reinfecting man must of course be borne in mind. That it may be a common disease amongst parrots is shown by the fact that of 700 birds examined by Fröhner* between 1881 and 1894 no less than 24·3 per cent. were tuberculous.

Preventive Measures to be effective must be thorough. All the birds should be killed off, as the salvage of one or two favourites will probably mean reinfection of the ground and of any fresh stock. Poultry houses must be thoroughly disinfected, and after a preliminary cleansing the free use of the painter's lamp on all woodwork is to be strongly advocated. Houses and pens should be shifted to fresh ground, and the soil whereon they stood dug up and disinfected by mixing therewith an abundance of quicklime. Fresh birds should not be introduced unless and until the ground has been cleansed as well as may be and left vacant for some weeks.

OVINE TUBERCULOSIS.

Tuberculosis in the sheep is very uncommon. Ostertag† has noted several cases in Germany, and one or two instances of a natural infection in this country have been described by M'Fadyean. The sheep is easily infected experimentally with tuberculosis, and its rarity in this species is undoubtedly due to the out-door life which sheep live. It is rather difficult to understand why cases are not at times seen amongst lambs when one takes into consideration the fact that they are frequently reared on cows' milk, which, though warmed, is not as a rule sterilized. Special preventive measures do not seem to be called for.

CANINE AND FELINE TUBERCULOSIS.

The disease is not infrequently met with in dogs and cats, and is more often seen in large cities, in fact it is very common in town cats. Infection may occur either by ingestion or by inhalation, chiefly by the former. Cows' milk and butchers' offals are often sources of infection, but Gray considers that the disease is usually contracted from man. Animals must be considered to be dangerous owing to the possibility of infecting persons with whom they come in contact. Dogs, and particularly adult dogs, are highly

* Hutyra and Marek, *Spec. Path.*, Vol. I., p. 615.

† *Journ. Comp. Path.*, 1891, Vol. IV., p. 361, Abs.

resistant to infection by ingestion, and many attempts at transmission by the Royal Commission were negative.

Schornagel* examined 11 cases of tuberculosis in dogs; from 4 of these he isolated bacilli of the human type, from 2 the bovine type, the other cases being either doubtful or no cultures being obtained.

Preventive Measures.—Intimately associated as the disease is between human beings and dogs and cats, preventive measures must be reciprocal. Phthisical patients should follow the dictates of hygiene and see that their sputum and discharges are destroyed. The fulsome intimacy too frequently observed between human beings, especially women, and their canine and feline pets should be discouraged by medical and veterinary practitioners. If suspicion arises that a cat or a dog is tubercular the tuberculin test should be applied. All known or even strongly suspected cases ought to be destroyed at once. Kennels, cages, feeding utensils, &c., must be thoroughly cleansed and disinfected. Rugs, coats and such like gear should be destroyed.

JOHNE'S DISEASE.

Johne's disease, or chronic bovine pseudotuberculous enteritis, caused by a specific micro-organism resembling in some respects the tubercle bacillus, is characterised in its later stages by a profuse diarrhœa and wasting.

The first case was described by Johne and Frothingham in 1895, and since that date the disease has been found to exist in many other European countries. M'Fadyean† was the first to draw attention to it in this country in 1907, and since then it has been discovered to be very widespread. Twort and Ingram ‡ in 1910 were the first to grow the organism on certain special artificial culture media, and their results were confirmed later by Holth in Denmark and by M'Fadyean, Sheather and Edwards in this country.

Cattle are principally affected, though the disease also exists to a lesser extent amongst sheep and goats, and there is evidence that the disease may exist in the two latter species independently of cattle. Stockman§ first described the disease in sheep in a flock

* *Journ. Comp. Path.*, 1907, Vol. XXVII., p. 88, Abs.

† *Journ. Comp. Path.*, 1907, Vol. XX., p. 48.

‡ Monograph on Johne's Disease, 1913.

§ *Journ. Comp. Path.*, 1911, Vol. XXIV., p. 66.

in which 12 out of 65 animals were attacked. Deer and buffaloes have also been attacked naturally.

The period of incubation is very long. In experimental cases in which large doses of infective material were given it has been found to be about six months, but in natural cases it is longer, and as a result the disease is only encountered in cattle at least a year old. The organism is strictly obligatory, and in practice it has been found that cases over a period of years always have some connection with antecedent cases. The natural method of infection is by ingestion. M'Fadyean and Sheather* found that cattle and sheep appear to offer a marked natural resistance to experimental infection. They also failed to transmit the disease to horses by intravenous inoculation with large doses. Every case in which symptoms appear is fatal, though fluctuations are often seen in the course of the disease. Owing to the chronic diarrhœa which is seen in practically every case, it is obvious that infection is spread far and wide by diseased animals. Pastures become heavily contaminated, and the virus thus finds its way into food and water. It is not known with certainty how long the bacilli can maintain their vitality in contaminated pastures, &c., but like tubercle bacilli they are fairly resistant to adverse conditions and consequently are probably capable of producing infection some time after being voided from the body.

Preventive Measures.—Although M'Fadyean states that probably 90 per cent. of cases of chronic diarrhœa occurring all over the world are cases of Johne's disease, the difficulties of prevention are somewhat enhanced by the fact that there is no very certain method of diagnosis in the case of infected animals which are not showing well-marked symptoms. In this connection it must be remembered that an animal may be distributing infection through the medium of its fæces for some time before any marked wasting or diarrhœa becomes evident. Preventive measures include destruction of clinical cases and rigid isolation of suspected animals. Those showing only slight symptoms should receive particularly good feeding with a view to being handed over to the butcher at the earliest moment. The animals should be kept stalled in order to limit the spread of infection, and all fæces and litter should be spread on arable land and ploughed in. If practicable pastures known to have carried infected animals should be kept clear of ruminants for at least a season. Sheep suffering from disease in any respect simulating Johne's disease should be carefully examined and if affected should be slaughtered. Sheep owners should be

* *Journ. Comp. Path.*, 1916, Vol. XXIX., p. 62.

encouraged to court professional inquiry into the ailments of their stock. The houses from which infected animals have been removed must be cleansed and disinfected.

M'Fadyean, Sheather and Edwards* have prepared a diagnostic agent to which they applied the term "johnin" and which is analogous to tuberculin. This agent produces a rise of temperature on being injected into infected animals, but the results are unfortunately invalidated to some extent by the fact that reactions are also produced in tuberculous animals.

Experiments on similar lines had been previously made by Twort and Ingram as soon as it was found by these authors that the organism could be cultured artificially. It had previously been noted by O. Bang that avian tuberculin in the same way produces a reaction in animals infected with Johne's disease. Should cases appear in a herd it would appear to be advisable to subject the whole of the animals to a preliminary tuberculin test with the object, if possible, of ruling out tuberculosis. After an interval of a month non-reacting animals might then be tested with johnin, and any then reacting should be regarded as infected with Johne's disease.

TETANUS.

Tetanus (lockjaw) is a disease caused by a specific micro-organism, the *bacillus of tetanus,* discovered by Nicolaier in 1884, and is characterised by spasmodic contractions of the voluntary muscles of various parts of the body.

The tetanus bacillus is a strictly anærobic organism which normally maintains a saprophytic existence in soil, and especially in soil which is contaminated with horse manure. It is also said to be specially numerous in swampy ground. Its very wide distribution is shown by the fact that Bassano found the tetanus bacillus in 27 out of 43 samples of soil obtained from various parts of the world. Its special association with ground contaminated with horse manure is due to the fact that it is normally found in the intestinal tract of the horse.

The distribution of the disease is universal but it is much less frequent than one might expect. It is said to be more common in warm than in cold climates. It is usually sporadic, but in young animals it is sometimes enzootic, for instance, in lambs and sometimes in foals following umbilical infection (*tetanus neonatorum*). Any special incidence as to season or age is merely coincident with such operations as sheep shearing, castration, &c.

* *Journ. Comp. Path.,* 1916, Vol. XXIX., p. 134.

All animals and man are susceptible to tetanus, but the disease is more frequently encountered in equines, although, as mentioned above, it is occasionally seen in the form of enzootics among lambs and also among young pigs. Cattle and dogs are less susceptible, and cases occur less commonly in these species. Fowls are very resistant.

The disease follows the inoculation of a wound with material containing tetanus bacilli or their spores, and consequently soil, manure, and stable dust are especially dangerous. It is before all punctured or lacerated wounds which are liable to be complicated by tetanus, and infection is favoured by the simultaneous presence of other bacteria.

Any wound which contains much necrotic tissue, decomposing blood clot or pus will form an especially suitable nidus for the development of the organism.

The tetanus bacillus exerts its action through the medium of a very powerful toxin, which is elaborated as the result of its growth. In practice, cases of tetanus are noted to follow most frequently certain injuries such as picked-up nail, pricks during shoeing, and harness galls. Infection may also follow dental caries. The shearing of sheep, castration, and docking of foals, lambs and calves produce wounds which are not uncommonly followed by tetanus. The application of the actual cautery leads to a certain amount of necrosis, and a suitable site for the growth of the bacillus may in this way be created. Parturition in the cow has been followed by tetanus as the result of wounding of the genital passages.

When the disease arises as the result of a discoverable wound it is sometimes spoken of as "traumatic tetanus" as opposed to cases of so-called "ideopathic tetanus" in which a careful examination fails to reveal the point of infection. It is probable that there is no such thing as "ideopathic tetanus," and in this connection it must be remembered that infection may occur through very minute abrasions, *e.g.*, in the intestinal tract.

The period of incubation may be set down at from about 3 days to 3 weeks. Hutyra and Marek* state "that in most cases in horses symptoms appear from 1 to 2 weeks after infection." Cadiot noted that of 38 cases in horses symptoms appeared in 28 between the 5th and 20th days. According to Hoffman, the period of incubation of "parturition tetanus" in cows is 2 to 14 days, and in rams and boars after castration, 8 to 14 days. Dieudonné has reported 58 cases of tetanus following docking, in which the period

* Hutyra and Marek, *Spec. Path.*, Vol. I., p. 449, Trans.

of incubation was 8 to 42 days. It would appear, however, that symptoms frequently arise as early as the 5th day following this operation.*

The mortality is somewhat uncertain. Wallis-Hoare says "that it is estimated to be from 70 to 80 per cent." It is certain, however, that in young animals, and especially lambs, it may be as high as 95 to 100 per cent. According to Nocard the only cases which recover are those in which progress is slow to begin with, though by no means all chronic cases recover. Death usually occurs in 3 to 10 days after the appearance of symptoms, and the prognosis is decidedly more hopeful if cases survive the second week. In general it may be said that the course of the disease is variable.

PREVENTIVE MEASURES.—Suitable surgical treatment of soiled, and especially of punctured and lacerated wounds, aseptic surgery and careful application of the actual cautery are obviously indicated. Frequent flushing of wounds with any oxidising antiseptic, *e.g.*, hydrogen peroxide, is indicated. The pricking of horses by smiths should always be reported by them to the person in charge of the horse, when appropriate surgical treatment can be applied. Care should of course be taken that the sterilization of instruments and suture material is complete, though surgical tetanus is far more rare than accidental tetanus. Newly born and freshly castrated animals should be turned into houses in which by means of clean bedding risk of soil contamination of their wounds is reduced to a minimum. In localities in which cases of tetanus frequently occur injections of antitetanic serum should be made whenever it appears likely that a case may occur, *e.g.*, after operations.

One attack does not produce immunity, and renewed infection results in the reappearance of symptoms. A very efficient antitoxic serum is available for the prevention of tetanus. The serum is prepared from horses, the principle being to inject gradually increasing doses of toxin at frequent intervals. Roux and Vaillard commenced the process of hyperimmunisation by injecting toxin which had been attenuated by treatment with a slightly iodised solution (Lugol's solution) followed by increasing doses of pure toxin. In the later stages of hyperimmunisation the horse can often stand an injection of 250 to 300 cc. of toxin, which according to Nocard would be sufficient to kill 2500 untreated horses. While the serum is of very great value as a prophylactic, it appears to be of no great service once symptoms have appeared. Nocard† was

* References to Cadiot, Hoffman and Dieudonné—see Hutyra and Marek, *Spec. Path.*, Vol. I., p. 449, Trans.

† Hutyra and Marek, *Spec. Path.*, Vol. I., p. 462, Trans.

unable to check the course of the disease even by intravenous injections of serum undertaken 24 hours before the appearance of symptoms. The serum confers a passive immunity which lasts at most for 3 or 4 weeks. Injections should, therefore, be continued at fortnightly to three-weekly intervals until the wound has completely healed.

ANTHRAX.

Anthrax (splenic apoplexy, splenic fever) is an acute affection caused by a specific organism, the *Bacillus anthracis.* Its contagious character has been known since 1836, and the etiological significance of the bacilli was first demonstrated by Davaine in 1865. The organism is facultative. During the greater part of the year in temperate countries no multiplication can occur owing to the temperature being too low. However, even when the temperature is favourable it is doubtful if it multiplies to any extent. All the mammalia, including man, are susceptible. Of domesticated animals cattle are the most frequent victims followed by pigs, horses and sheep in the order given. It is a curious fact that sheep, although highly susceptible to experimental inoculation, are in nature somewhat infrequently infected with anthrax. Though it is possible that the disease is more common among sheep than is usually supposed, it is probably rare. The dog is more resistant, but nevertheless (in Great Britain at any rate) has not a great immunity against anthrax. It is difficult to infect poultry. While young cattle are certainly as susceptible as adults, if not more so, M'Fadyean has remarked in 39 outbreaks described by him that most cases occur in adults.

Anthrax is universal in its occurrence. Its distribution in the United Kingdom is peculiar, some districts, though carrying a large cattle population, being comparatively free from it while other districts show a high mortality return. The following table, compiled from the official returns, shows the number of cattle attacked, the cattle population and the number attacked per hundred thousand head for the four divisions of the United Kingdom, the latter calculated on the average for the three years shown :—

	Cattle Census and Cattle attacked.				
	1912.	1913.	1914.	Average.	No. per 100,000.
England, .	5,087,455 487	4,991,208 326	5,119,445 422	5,066,036 412	8·1
Scotland, .	1,184,376 247	1,246,910 278	1,214,974 306	1,215,420 277	22·8
Wales, .	754,265 12	725,736 6	758,499 5	746,167 8	1·0
Ireland, .	4,848,498 2	4,932,625 Nil	5,051,645 1	4,944,256 1	·02

That the prevalence of anthrax is not in proportion to the number of cattle is strikingly shown in the following figures taken from the annual report, Chief Veterinary Officer, Board of Agriculture for 1914,* Devon with 303,214 head of cattle had 10 attacked; Aberdeen with 179,078 head had 93 attacked. This is at the rate of 3·3 deaths per 100,000 head for Devon and 51·9 deaths per 100,000 head for Aberdeen. Outbreaks among horses and pigs may be regarded as subsidiary to cattle outbreaks.

With regard to seasonal incidence, Stockman has laid emphasis on the fact that there is a marked and constant drop in the number of outbreaks during the third quarter of the year, that is when the animals are at grass. This depends upon the now well recognised fact that in a very large proportion of outbreaks in cattle, infection has been introduced through the medium of artificial feeding stuffs which have been imported from countries in which anthrax is prevalent. The probability is that cake, meal, &c., becomes contaminated during shipment from dried hides which are often stowed on top. The detection of anthrax spores in food which has presumably been the source of infection has not, as a rule, been attended with success, though M'Fadyean and others have been successful in some instances. One such case occurred in London in 1895, in which 14 horses died after eating a certain sample of oats, and M'Fadyean was successful in finding anthrax bacilli in the consignment by means of inoculation. Anthrax is thus usually conveyed to animals by ingestion. Another source of infection is the use of bone manure, but this material is more likely to be rendered harmless owing to the chemical processes through which such manure passes. That infection from this source is not very

* Cd., 7852, 1915.

common is also evidenced by the fact that the incidence of anthrax does not run parallel with the use of such manures, *e.g.*, in proportion to its cattle population Aberdeen has 15 times as much anthrax as Ayr, whereas there is no reason to suppose that less bone manure is used in the latter county. In a further proportion of outbreaks, infection can be traced to a previous case of the disease, the ground having become grossly contaminated by blood or excretions containing the virus. That the incidence of anthrax is as a rule not dependent upon previous cases has been shown by Stockman, who has remarked on the fact that in 83·5 per cent. of outbreaks covering a period of 5 years (1902 to 1906) the disease had not previously existed on the farm, and it does not follow that in the remaining 16·5 per cent. the source of infection was a previous case. From the records of 12 years (1895 to 1906) it appeared that in only 4·6 per cent. of cases had the disease occurred a second time during any one year upon the same farm.*

It therefore follows that the infection of animals can be divided into two groups (*a*) those which are in a sense accidental, and the prevention of which is very difficult if not largely impossible; and (*b*) those in which infection spreads from the original case to other animals owing to carelessness or ignorance and is therefore preventable. As stated above, the chief sources of infection in the first group are imported feeding stuffs and, to a less extent, artificial manure. Refuse and drainage from wool factories and tanneries cause annually a few cases. The following notes, taken from the annual report of the Chief Veterinary Officer of the Board of Agriculture for 1915 will convey some idea of the more common sources of origin. For 438 outbreaks on previously clean premises, the following were regarded as the probable sources of infection :—

(1) Effluent from tanyards getting into streams	4	outbreaks
(2) Sewage on pastures	5	,,
(3) Feeding of carcase offal to pigs . .	5	,,
(4) Use of imported feeding stuffs . .	265	,,
(5) Use of artificial manure on the land .	41	,,
(6) Use of both artificial manure and feeding stuffs	70	,,
(7) A recent death, not reported, but not improbably anthrax . . .	6	,,
(8) No explanation obtainable	42	,,

Sporadic cases of anthrax, when due to the use of foodstuffs

* *Journ. Comp. Path.*, 1911, Vol. XXIV., p. 103.

of foreign origin or of contaminated fertilisers, are obviously largely out of control, and such outbreaks must continue to occur so long as foodstuffs are imported from countries where the disease is of an epizootic nature. As the chief Veterinary Officer in his report for 1913 says: "The incidence of anthrax in this country depends largely upon factors which cannot be controlled by the Anthrax Order. The Order is designed to control the spread of anthrax once a case has occurred on premises and to prevent a recurrence of the disease. That it is successful in these respects is borne out by the fact that the disease recurs on the same premises in only a small minority of cases, and the number of deaths per outbreak is usually below two."

When outbreaks do occur which fall within the second or preventable group, they are usually due to the cupidity of a dairyman who cuts the throat of a sick cow in an attempt to salve the carcase for human consumption; or the animal may have died and it is skinned for the sake of its hide.

In man the disease is contracted, as a rule, through inoculation of cutaneous abrasions on the hands and arms when the carcase of an animal that has died of anthrax is skinned, or when such an animal is slaughtered and dressed. Cattlemen, butchers and knackers are liable to infection under these conditions (malignant pustule). Anthrax is also conveyed to people by handling infected hides or their products. Infection may also occur by inhalation, especially when the fleece or hide is dry (wool-sorters' disease). Some observers (Morris)* have considered that bloodsucking flies are responsible for transmitting infection, but it is very probable that this possible source of anthrax has been largely overestimated. Evidence has also been brought forward to show that infection may be distributed by carrion-feeders, thus anthrax spores have been recovered from the fæces of a dog 6 days after the material was fed, from the fæces of swine after 5 days, &c.

The period of incubation is probably not longer than 3 days naturally in the horse and ox. Sheep fed on large quantities of spores usually die in 2 or 3 days, but the period is longer than this naturally owing to the doses of infective material being smaller (Hutyra and Marek). The rate of mortality is difficult to estimate; it is probably about 80 per cent.

There is not the least doubt but that many animals become affected and recover. Such instances have been recorded personally to the author, and in this connection it is interesting to note what the Chief Veterinary Officer of the Board of Agriculture

* *Journ. Comp. Path.*, 1918, Vol. XXXI., p. 134, Abs.

says in his annual report for 1914: "In an outbreak of anthrax among swine 1 sow died of the disease. The owner asserted that 6 fellow sows, which had an equal opportunity of becoming infected, showed similar symptoms to those displayed by the dead sow, but they recovered after a few days' illness. There was no veterinary evidence in support of the owner's opinion that the 6 sows had been infected and recovered. It is, however, not improbable. In another outbreak 7 cows died out of a total of 21 cows grazing in the same meadow. The veterinary surgeon in attendance reported that several of the remaining 14 cows had temperatures up to 107° F. and subsequently recovered."

The course of the disease varies with the species, the period of visible illness being short in cattle and sheep, the animals often being found dead. In the horse and pig it is more subacute and often lasts several days. The disease being septicæmic the bacilli are innumerably present in the blood at the time of death of cattle and sheep as well as in the excretions of the body before death. Anthrax bacilli can probably be found in the milk in the majority of cases in cows. As pointed out by M'Fadyean,* however, there is little risk of infection of human beings occurring from this, as the bacilli do not pass into the milk until the general blood invasion has taken place, and this does not happen until an hour or two before death. In an outbreak, therefore, it is sufficient to take the temperature of the incontacts before milking and to reject the milk of any animal showing a rise.

Preventive Measures.—It is doubtful if anthrax can ever be entirely stamped out from Great Britain, but a great deal is being done to prevent outbreaks from spreading, and with compulsory notification of all deaths from unknown causes much more might be done.

Anthrax is a notifiable disease; disposal of carcases of animals suspected to have died of the disease is under the control of the Local Authority, being supervised by and carried out to the satisfaction of the Veterinary Inspector for the Local Authority. Effective destruction of the infected carcases, soiled litter and dung is of the first importance. Under the Order carcases may be either buried or cremated. If the former method is adopted, the grave must be of such a depth that the carcase is 6 feet below the level of the surrounding soil. It is usually advised that it be thickly covered with lime but this precaution is probably hardly necessary. There is little danger of subsequent infection of other animals if burial is immediate and deep and the carcase has not been mutilated. In

* *Journ. Comp. Path.*, 1909, Vol. XXII., p. 148.

this connection it should be observed that the bacilli in the carcase not only do not sporulate owing to the fact that free oxygen is necessary for this to occur and that for the greater part of the year the temperature is too low, but also that they rapidly disappear with the onset of putrefaction. Hides of anthrax carcases must on no account be slashed or cut in any way (compare foot-and-mouth disease and swine fever).

The method to be adopted in dealing with an anthrax infected carcase depends upon the locality and circumstances under which it is found. In all instances the carcase must be strictly isolated and prompt measures taken to prevent the spread of the infective material, such as pulmonary discharge or exudations from the anus, vagina, &c., and to prevent access to it of dogs, vermin and, if possible, flies until such time as the grave or crematorium is ready for its reception. Should the animal be one of a number of cattle in a byre, those adjacent should be immediately removed and placed by themselves, not only to prevent them becoming contaminated, but also to keep them under observation. If obtainable, some absorbent such as peatmoss, sawdust, &c., should be scattered thickly on any discharges to prevent them running down the fæces channel or across the stall. Dung recently passed should be collected from the channel and placed alongside the carcase until it can be dealt with. The channel behind the stall should then be well soaked with carbolic acid or other strong disinfectant. Precaution should be taken to prevent infected dung from being thrown out as manure, and at the same time infected material must be prevented from travelling down the channel to the danger of other cows in the byre. The carcase should then be covered with old sacking soaked in some disinfectant to prevent flies as far as possible from feeding off the infective material. It is better to leave the carcase in the byre until it can be definitely disposed of than to drag it outside, where it would be more exposed to attacks by vermin and dogs. Should the carcase be in a field, temporary fencing of hurdles stuffed with furze will keep off dogs and foxes during the night. The removal of the carcase to the grave must be done with the greatest care. The rectum, vagina, nostrils and mouth must be stopped with wool or tow soaked in crude carbolic acid or other suitable disinfectant. This is not easily done, but neglect to take every precaution to prevent discharges from soiling the ground during transit of the carcase is a serious matter. The carcase should be handled as little as possible; farm labourers are not able to appreciate the grave risks run from manual contact with the blood-stained quarters or head, and the veterinary inspector

should supervise the whole proceedings personally. Old ropes should be tied to the legs and head and be destroyed with the carcase. The carcase is best conveyed to the place of destruction on some sort of trolley (a hurdle provided with runners is often the best obtainable) and should be securely fastened to it. Owing to the difficulty of completely closing the mouth and nostrils, and to the frequency with which virulent blood flows from these orifices when the carcase is on the trolley, the head should be bent backwards over the shoulder so as to keep it at a high level and be fixed in that position with ropes tied to the hurdle. If it is left to trail along the ground infection of the soil is certain to follow. It is impossible to take too much care during the transit of the carcase to the place of destruction. The ease with which infection may be conveyed is shown by the following remarks by the Chief Veterinary Officer of the Board of Agriculture in his annual report for 1914 :—" A horse which had been worked as a chain horse to a lorry employed in carrying hides in the Liverpool docks died of anthrax. A horse which had been used to drag a carcase of a cow which had died of anthrax from the shippon to the grave died of the disease."

All litter, dung and scrapings from the stall and its immediate vicinity must be carefully taken up and buried or burned with the carcase. Having removed the most obvious and easily removable dirt, the entire stall, manger and surroundings must be disinfected (see Disinfection).

The spores of anthrax are very resistant to agents which readily destroy the bacilli, and for this reason especial care must be taken when carrying out cleansing and disinfection of an infected place. Direct sunlight, heat, putrefaction, desiccation and disinfectants of moderate strength are germicidal to the bacilli when in the vegetative state. The spores, however, will withstand desiccation for a very great length of time, according to Miessner for 18 years.* Spores will resist dry heat at 140° C for longer than 2 hours. The bacilli when in manure at a temperature of 70° C to 76° C are killed in a few minutes, whereas the spores remain virulent under the same conditions for 3 or 4 days. " Chloride of lime " is destructive to spores in from 12 to 17 days, bichloride of mercury (1 to 1000) in 15 minutes, and 5 per cent. carbolic acid solution in 2 days (Miessner). Gastric juice is destructive to the bacilli but not to the spores.

Experiments carried out by Tilley† with regard to the efficacy of the Schattenfroh and the Seymour-Jones methods of disinfecting

* *Epizootics and their Control during War*, 1917, p. 88.

† *Journ. Comp. Path.*, 1915, Vol. XXVIII., p. 182, Abs.

hides contaminated with anthrax spores showed that the former gave the better results. The Schattenfroh method consists of soaking the hides in hydrochloric acid and salt, and Tilley found that at room temperature the acid should be 2 per cent. and salt 10 per cent. and the exposure for 48 hours. The Seymour-Jones method consists of soaking hides in formic acid, and later in mercury bichloride. Anthrax spores were found by Tilley to be destroyed by exposure for 2 hours to a mixture containing 1 : 2000 mercury bichloride and 1 per cent. formic acid in the presence of organic matter such as 10 per cent. defibrinated blood.

Immunity is conferred by one attack if the animal survives. Methods of vaccination are to be considered only in herds in which there is a steady annual loss from anthrax, and as such cases do not occur in Great Britain, a very brief notice only is necessary. The first, best known and most widely practised method of vaccination was that evolved by Pasteur which consisted in subjecting animals to two inoculations at an interval of about 12 days with bacilli attenuated in virulence. Though the method has done good service and produces immunity for about a year, experiments in Great Britain have shown that the method is not without risk and is at times inefficacious. A very efficient anti-anthrax serum has been produced which can be used with the greatest advantage in the case of animals which show high temperature in a herd in which the disease has already been diagnosed.

BLACK QUARTER.

Black quarter (quarter evil, quarter ill, blackleg, murrain) is an acute disease caused by a specific micro-organism, the *bacillus of black quarter,* and characterised by the development in some part of the muscular system of an inflammatory infiltration accompanied by emphysema and usually by darkening and necrosis of the over-lying skin. The disease appears with the greatest frequency in the ox, but it is by no means uncommon in the sheep, and experimentally sheep are more susceptible than cattle. Black quarter has been the cause of serious losses in sheep in Great Britain, but it seems that cases are not so often diagnosed in this species as in cattle. The goat is susceptible. The pig is usually considered to be immune, but cases of alleged black quarter in this animal have been described. Von Ratz* produced absolutely characteristic lesions by inoculation of two pigs with muscular tissue of cattle dead of

* *Journ. Comp. Path.,* 1914, Vol. XXVII., p. 175, Abs.

the disease. Cases have also been described in the horse by Ganter,* Hess and Semmer, but are open to doubt. Other animals, including man, are immune.

Black quarter occurs sporadically with a marked regional distribution. In some parts of the country the disease is practically unknown, while in other parts certain districts, farms, or even particular fields show a number of cases annually, and in this way the expression " black-quarter farms " has come into use. It thus appears that the organism like the tetanus bacillus is saprophytic in the soil of certain localities, and its existence is normally maintained in this way and not by multiplication within the animal body. It is important to remember, however, that a single case of the disease, if carelessly handled after death, is capable of producing very dangerous local contamination of the soil.

According to Butcher† cases are usually met with in late autumn, winter, and again in the spring, though they may be seen at any time of the year. The disease is rare in very young calves owing to the smaller risk of infection, and is most commonly met with in animals between the ages of six months and two years, though susceptibility varies within wide limits. In adult cattle it is rarely seen, this being probably due to susceptibility naturally diminishing with age. The notion that the disease was more liable to appear in animals receiving very rich diet or undergoing forced feeding is now happily generally abandoned, the idea having no foundation in fact. The sheep has no special susceptibility according to age.

The manner in which animals become infected is in a measure uncertain. Probably it occurs by ingestion in spite of the well-known fact that the disease has never been produced experimentally by feeding, even with enormous doses of the organism in culture. Some suppose that association with other organisms within the intestinal canal is necessary. Probably in certain cases animals become infected by inoculation, and M'Fadyean has noted small enzootics of the disease occur in sheep after shearing. The period of incubation is generally 3 days, but does not exceed 5 days. ‡

The disease has a very high mortality, and extremely few cases which have shown a well marked black-quarter " tumour " recover. It is stated, however, that at times the symptoms shown by the animal may be so slight as to escape notice, and that this occurs especially in herds in which the losses are frequently considerable.

* *Journ. Comp. Path.*, 1891, Vol. IV., p. 70, Abs.

† *Journ. Comp. Path.*, 1891, Vol. IV., p. 59.

‡ Hutyra and Marek, *Spec. Path.*, Vol. I., p. 47, Trans.

The virus in the spore form is very resistant. Putrefaction and desiccation have very little effect upon it. Five per cent. carbolic acid is only fatal to artificial cultures containing spores in 10 hours. Spores contained in natural products of the disease are much more resistant than when in artificial culture, especially when such natural products, *e.g.*, muscle, are dried before being heated. Thus the fresh muscle enclosed in a tube is rendered sterile in 2 hours at 80° C and in 2 minutes at 100° C, but if such muscle be quickly dried at 35° C and then mixed with water, 2 hours at 100° C are required to completely sterilize it (Arloing, Cornevin and Thomas).* Dried and powdered muscle may be heated to 100° C for six hours without being rendered completely sterile.

Preventive Measures.—Drainage and cultivation of the land take first place in the prevention of black quarter. Liming of pastures is also recommended. Should the disease appear frequently the infected pastures should be ploughed up and used for corn growing. If impossible to do this susceptible animals should be kept off such pastures, which should only be used for maintaining adult stock.

Affected animals if seen alive should be isolated, but the animal is often found dead without symptoms having been noticed. The carcase of an animal which died of black quarter should, if possible, be cremated owing to the fact that putrefaction has no destructive effect upon the virus. As a rule, however, this method is impracticable, and in any case costly, and in consequence one is thrown back upon burial. Burial should, if possible, be in a place to which cattle and sheep have no access, it should be deep and there must be no mutilation until, at any rate, the carcase is in the grave. Dung and soiled litter where the animal has been housed should be disposed of with the carcase. Carcases of animals dead of black quarter are quite unfit for human food.

One attack confers a considerable degree of immunity. The ancient practice of setoning has now fortunately to a great extent fallen into disuse, as no measure of protection is thereby afforded. A high degree of immunity can, however, be established by means of vaccination. To Arloing, Cornevin and Thomas and to Kitt special credit is due for having introduced the methods called after their names. These are shortly as follows :—

(1) Method of Arloing, Cornevin and Thomas: Pulp from a perfectly fresh black quarter lesion is spread in a thin layer on a plate and dried at 32-35° C; one part of the dry residue is triturated in a mortar with two parts of water to form a paste, which is placed

* *Journ. Comp. Path.*, 1898, Vol. XI., p. 148, Quotation.

on a plate in a thin layer and heated to 100° C-104° C for 7 hours in the case of the first vaccine and to 90-94° C for 7 hours in the case of the second. The dried vaccine is then ground up to a powder and mixed with sterile water in the proportion of 1 centigram to ½ c.c. liquid, which is the dose for a yearling calf. The injection is made beneath the skin near the end of the tail, and after ten days the injection of the second vaccine is made a little higher up. M'Fadyean showed that the vaccines of Arloing, Cornevin and Thomas can also be applied to sheep. (2) Kitt's method is a modification of the last, and consists in exposing the dried virulent muscle prepared as above to steam at 100° C for 6 hours. The material is then dried. One decigram of the dried powder is used as a single vaccine injected subcutaneously behind the elbow. The duration of immunity from each method is said to be about 1 year.

Both procedures, and especially that of Arloing, Cornevin and Thomas, have been in general attended with excellent results, the mortality in nearly half a million animals inoculated having been less than ½ per cent., while among animals uninoculated the mortality has reached 1·74 per cent. (figures given by Strebel quoted by M'Fadyean).* The disadvantages of the methods are that at times the mortality may in the case of individual herds amount to 2-5 per cent., due most probably to a more than usually high susceptibility on the part of certain animals. (3) Leclainche and Vallée † have devised a method which they say is safer and gives certain immunity. It consists in giving subcutaneously at the shoulder 10-20 c.c. strong anti-black-quarter serum, and in 5-8 days 1 c.c. pure culture which has been heated for 3 hours at 70° C. Of 648 animals from badly infected districts inoculated only ·15 per cent. died. If considered necessary a second vaccine heated to 65° C may be given.

MALIGNANT ŒDEMA.

Malignant œdema (hospital gangrene) is an acute inflammatory condition arising in connection with wounds and caused by an anærobic sporing bacillus, the *bacillus of malignant œdema.* The disease may be met with in all animals, but it is most frequently encountered in horses. The sheep is also susceptible, but the ox and dog are more resistant. The organism is a saprophyte and a normal inhabitant of the soil and of the intestinal canal of herbivorous animals. For this reason and owing to its comparatively

* *Journ. Comp. Path.*, 1898, Vol. XI., p. 157.

† *Journ. Comp. Path.*, 1903, Vol. XVI., p. 7. Trans.

rare occurrence the disease is not of great importance from a hygienic point of view. Infection occurs by contamination of surgical or accidental wounds with soil or manure. The wounds which become infected are as a rule those in which there has been considerable laceration of the tissues, and in which there has been a good deal of necrosis. Punctured wounds (*e.g.*, those produced by hay forks) are also especially liable. Malignant œdema also sometimes complicates castration, removal of scirrhous cords, sheep shearing, and difficult parturition. Oppermann* during a period of 5 years observed the disease to occur in 22 flocks of sheep following parturition. On one occasion in a flock of 350 animals 46 ewes died. The synonym "hospital gangrene" indicates that at one time the disease commonly occurred after operations, but at the present time this name is hardly justifiable. In any case the infection is always a mixed one, other organisms participating in the production of lesions. Any special seasonal or age incidence that there may be is entirely coincident with the operations above mentioned (castration, &c.).

Preventive Measures.—Those obviously indicated are suitable surgical treatment of wounds, namely, thorough opening up and cleansing followed by the use of copious flushings of oxygenating fluids such as hydrogen peroxide, &c. Shearing of sheep should be carried out if possible by means of special shearing machines. If the operation has to be done by hand, care should be taken to inflict as few injuries as possible. Lambing should take place in pens which are bedded down with clean soft straw.

EPIZOOTIC LYMPHANGITIS.

Epizootic lymphangitis (african farcy, neapolitan farcy, river farcy) is due to a specific micro-organism, the *cryptococcus of Rivolta* (1873), and is characterised by lesions which bear a strong resemblance to those of farcy. The disease is strictly contagious and is confined to equines. Epizootic lymphangitis which was first described in Italy, was introduced into Great Britain by army horses after the South African War (1902), but was stamped out by 1907. Since that date the disease has not made its appearance, though it still remains a scheduled disease. Infection occurs by inoculation of the organism through the skin, and though cutaneous injuries such as abrasions favour entry of the organism infection can apparently occur through sound skin. Spread from dis-

* *Vet. Rec.*, 1919, Vol. XXXI., p. 393, Trans.

eased to healthy horses is no doubt largely brought about by the indiscriminate use of grooming tools and harness, the organism being abundantly present in the pus from the lesions. Many observers regard flies as being important agents in the spread of the disease. The existence of the cryptococcus is largely maintained by the insidious nature of the malady. The period of incubation is as a rule very prolonged, *e.g.*, Perrin* noted that in 5 cases the average period was 118 days, and Drouin believes that it is never less than three months. It is thus easily understood how new centres are established by the sale of apparently healthy but in reality infected animals. The disease is not as a rule fatal, though the duration in untreated animals is very long. Cases are generally slowly progressive, and tend to recur after apparent recovery. The cryptococcus is very resistant to destructive agencies, and especially to chemical disinfectants. There is reason to believe that discharges in a stable may maintain their virulence for at least a month.†

Preventive Measures.—Any cases of the disease occurring in Great Britain have by law to be destroyed. Prevention of this disease calls for a vigorous attitude on the part of the hygienist due to the prolonged incubation period, the resistance of the organism to ordinary antiseptics and to the tendency of the disease to recur. After the destruction of cases diagnosed a very close watch upon contacts is necessary. The stud cannot be declared free until six months after the infected animals have been destroyed. Greatest care must be exercised in disinfecting grooming tools, clothing, &c., as pointed out by Olver. ‡ Heat should be the disinfecting agent used, as the organism is so resistant to disinfectants of a chemical nature. Sponges must not be used, and in hospitals it is important to forbid the indiscriminate use of swabs and antiseptic fluids; all such should be discarded after first use. To prevent introduction from countries in which the disease occurs animals should be carefully examined at the port of entry.

The two following diseases bear in some degree a resemblance to epizootic lymphangitis and to farcy in their clinical characters, though not as a rule so severe and in no case so serious from the point of view of the hygienist.

1. Ulcerative Lymphangitis or Ulcerative Cellulitis.—Due to the *bacillus of Preisz-Nocard,* which chiefly affects equines but is also met with in various lesions in other animals, *e.g.,* caseous pneumonia of sheep. It is also encountered at times in other skin

* *Trop. Vet. Bull.,* 1917, Vol. V., p. 183.

† Report, C.V.O., Bd. of Agric., 1905.

‡ Wallis-Hoare, *Syst. Vet. Med.,* 1913, Vol. I., p. 1300.

lesions in equines, *e.g.*, pustular dermatitis, wounds of the pastern, &c. The distinction from farcy was first pointed out by Nocard* in 1892, and a detailed description of the organism given by him in 1896. The same organism had previously been isolated by Preisz in 1891 from lesions in a sheep. The disease shows little tendency to spread by contagion, and of 19 cases described by Nocard only 2 came from the same stable. The course is variable; as a rule the disease progresses for a time and recovery then takes place, but sometimes death ensues as the result of the occurrence of metastatic lesions. A considerable number of cases of lymphangitis due at least in part to this organism have been met with in army horses during the war, and a certain measure of success has attended the use of serum from hyperimmunised animals and of vaccination procedures with dead bacilli. A few cases among army horses have been proved to occur in Great Britain during the war.

2. Sporotrichosis. — Due to a hyphomycete, *Sporotrichum equi,* probably identical with *Sporotrichum beurmanni,* which has been noted to cause multiple abscesses in man. The organism probably exists as a saprophyte, causing sporadic cases to occur on gaining entrance to wounds or abrasions.

The disease is slowly progressive, though not as a rule serious, and is rarely fatal. A few cases have been proved to occur during the war amongst army horses in Great Britain. Cases are more frequently encountered in the United States of America. The organism which is contained in the discharges from the abscesses can remain alive for considerable periods outside the body. It can live for at least three months in dry pus at 7° C.

On encountering cases of lymphangitis in horses the proper thing is to isolate and apply the mallein test. If either of the last two-named diseases, or a simple infection due to pyogenic micrococci, be diagnosed, it is wise to continue isolation until recovery has taken place, when the stalls or boxes may be disinfected. Heroic measures such as slaughter are not necessarily indicated as soon as a Preisz-Nocard or a sporothrix infection is diagnosed.

ACTINOMYCOSIS.

Actinomycosis (wooden tongue, lumpy jaw) is a disease characterised by the formation of inflammatory growths following inoculation with a vegetable parasite of the streptothrix species, the *actinomycis bovis* or ray fungus. At one time it was not looked upon as a disease *per se,* cases being referred to tumour

* Nocard and Leclainche, *Maladies microbiennes des animaux,* Vol. II., p. 171.

formation or to tuberculosis. Streptothrix infection is most frequently observed in connection with the tongue or jaw of cattle, but there are several varieties of streptothrix organisms, and cases due to one or other variety are seen occasionally in all the domesticated animals and in man. In the horse streptothrix infection is occasionally met with affecting the submaxillary lymphatic glands, in which situation it may be confused with strangles or glanders. It has also been observed to follow castration, the severed end of the spermatic cord being the seat of an actinomycotic tumour. M'Fadyean* described the first recorded case in this country. In swine, primary mammary actinomycosis is a not infrequent lesion.† Inoculation may also occur at the tonsils in these animals (Johne).‡ The disease is very rare in sheep and goats. It is a common disease in most parts of Europe. Its distribution in Great Britain though very general is somewhat irregular, and it is said that low-lying damp areas favour the growth of the offending organism. Some farms and districts are rarely free from the disease, while in other parts it is practically unknown. Isolated cases may occur on farms with wide intervals of freedom from the disease. The organism is facultative, and there is a good deal of evidence to support the view that it is parasitic upon various plants, especially upon cereals and above all on barley. Streptothrix organisms indistinguishable from the actinomyces have been shown to exist on barley, and Johne§ observed colonies attached to vegetable particles in the tonsils of pigs, and in the diseased tongues of cattle. Though cases are most frequently seen in barley-growing districts, the disease occasionally occurs among cattle on marshy land which are getting no cereal food. Consequently, it is probable that the actinomyces is also parasitic on certain other grasses. The method of infection is through direct inoculation by cereals carrying the parasite and especially by barley, the awns of which from their structure being especially likely to cause injuries. Infection is in some instances probably favoured by the swollen and raw condition of the gums which accompanies shedding of the teeth. Any injury to the skin may be followed by the formation of actinomycotic lesions, *e.g.*, through wounds caused by barbed wire, &c. Gooch|| witnessed the formation of actinomycotic tumours in 21 animals following the operation of setoning. Unweaned animals

* *Journ. Comp. Path.*, 1888, Vol. I., p. 49.

† Hutyra and Marek, *Spec. Path.*, Vol. I., p. 655.

‡ Hutyra and Marek, *Spec. Path.*, Vol. I., p. 656.

§ Hutyra and Marek, *Spec. Path.*, Vol. I., p. 647.

|| *Journ. Comp. Path.*, 1894, Vol. VII., p. 59.

are naturally less exposed to infection than those eating uncooked fodder; they are, however, not immune, as in some instances they have become infected from actinomycotic lesions of the udder. In general, however, as might be expected it is more often seen in stalled animals than in animals at pasture, and in winter and spring corresponding to the season of dry feeding. In man infection has occurred owing to the habit of chewing straws, and also it is said by inhalation during threshing.

The course of the disease is always chronic and may extend over months or years, though with suitable treatment most cases recover. That the disease is only slightly contagious is evident from clinical experience and from the experiment of Salmon who caused 21 healthy animals to be closely stalled with diseased animals for four months, with the result that none of the former became affected.

The actinomyces shows considerable resistance to destructive agencies, *e.g.*, cultures remain alive at ordinary room temperature for a year or more, and dry "spores" withstand continuous exposure to sunlight for 238 hours (Berard and Nicolas).* J. Russell Greig made careful post-mortem examinations of over sixty cases of bovine actinomycosis. He found that there were more or less extensive lesions present in the stomachs (rumen and reticulum) in 25 per cent. of cases, with in many instances metastatic infection of the relative lymph glands. In the great majority of such cases primary lesions were found within the buccal cavity, usually on the hard palate, gums and commissures of the mouth. The tongue was affected in only 15 per cent. of cases. In one case there was a generalisation of the disease apparently confined to the systemic lymphatics, and in two cases primary but extensive lesions of the skin were met with. The lungs and pleura and the liver in the case of stomach infection are also fairly commonly seats of the lesions. The above findings suggest, as Russell Greig points out, that actinomycosis is a much more common affection of cattle than is generally supposed. When extensive infection of the stomachs exists it is accompanied with great emaciation, the animal giving a clinical picture resembling that of the advanced stage of tuberculosis.

Preventive Measures.—The proper drainage of low damp pastures is indicated. If numbers of cases are appearing, it would be advisable to steam or soak the food with the object of softening its consistency and so lessening the liability to traumatism. Though direct inoculation from one animal to another does not appear to be frequent, precautions should be taken to isolate

* Hutyra and Marek, *Spec. Path.*, Vol. I., p. 645.

infected animals. In connection with this it should be observed that the cases which are particularly dangerous are those in which lesions are discharging, *e.g.*, jaw lesions in cattle. In this way one prevents the pus contaminating fields, common feeding boxes and the like. Discharges should whenever possible be collected and destroyed, and soiled litter should not be used as manure. Isolation of cases should be accompanied by treatment with potassium iodide, which in a longer or shorter period renders the animal safe.

RINGWORM.

This is a parasitic disease of the skin due to the pathogenic fungi *Dermatophytes* or *Dermatomycoses.* Those producing skin lesions in the domestic animals are classified as follows:—*Trichophyta, Eidamella, Microspora, Achoria, Lophophyta* (fowls) and *Oöspora.*

Infection occurs by direct or intermediate contact, and the spores or conidia are air-borne. The conidia retain their vitality for a considerable time away from the body, and are not easily destroyed by mild antiseptics. They settle on the skin, bud out into hyphæ which, rapidly branching and rebranching, form the web-like mycelium; this in turn produces fresh spores in the terminal sporangia or conidiophores. There is also a complicated sexual propagation. As the growth of the fungus proceeds the area of infected skin becomes depilated, prurius and erythema set in with often slight secondary abrasions, the result of scratching, biting, &c. The exudate which forms on the abraded surface dries into a pinkish, sulphur-yellow, greyish, whitish, or even violet-coloured crust according to the variety of the fungus present and the animal host. Under this crust or scutula suppuration sometimes occurs. The tendency of ringworm is to become chronic in housed animals, but given no re-infection it will spontaneously disappear in 40 to 50 days in the horse and in 6 to 12 weeks in cattle.

Ringworm in Horses.—Horses are affected by *Microspora* and *Trichophyta.* The *microspora* affects foals and young animals in the spring and early summer, and those that are kept housed for considerable periods are especially susceptible. Once the animals get out in the open and are exposed to the sun and wind recovery spontaneously takes place. *Trichophyta* is found mainly on adult horses that are herded together such as under conditions of war, in dealers' yards, &c. Ringworm in the horse is very contagious but readily yields to treatment. *Microspora* and *trichophyta* are

transmissible between horses, asses, dogs, cattle and man. Sheep, goats and pigs may be affected but are not so susceptible as the foregoing.

Ringworm in Cattle. — *Trichophyta* are mainly responsible among cattle for the most commonly met typical ringworm. Animals enclosed in buildings during winter and spring, especially calves, yearlings and fattening bullocks, are particularly susceptible. The system of housing store beasts in damp enclosed sheds and loose boxes, where sun never and fresh air seldom gain entrance, is calculated to foster the pathogenicity of the spores. Only in grossly neglected cases does ringworm ever cause anorexia, emaciation and death; but it is a serious cause of loss of condition, and is especially bad in wet and marshy districts. The ringworm of cattle is often transmitted to horses and men.

Ringworm in the Dog.—*Trichophyta, Microspora, Eidamella,* and *Oöspora* are met with in the dog. The first and second, and the last (which causes the evil-smelling favus of dogs), are the most common. *Eidamella* is very rare. Ringworm is most frequently seen in kennels where numbers of dogs such as foxhounds are kept together, and is mainly seen in winter. Young dogs are more susceptible than adults. All the varieties attacking the dog are transmissible to man.

Ringworm in the Cat.—*Achoria* and *Microspora* are frequently found on the cat, and both may be conveyed to man.

Preventive Measures.—Animals should be kept under good hygienic conditions, the feeding must be adequate and sufficient exercise should be allowed to keep the animals in a good healthy condition. Infected animals should be promptly isolated and suitably treated. Fresh air and direct sunlight are inimical to the growth of the fungus. Exposure to winds causes a partial desiccation and wasteful distribution of the spores when the animals are out in the open air and there is thus less chance of one animal affecting another than is the case when the animals are confined in cattle courts, &c. Ringworm is amenable to treatment in the early stages, and no time should be lost in treating those animals that are affected so as to reduce the risk of the disease spreading among the rest of the stock.

Harness and equipment should be disinfected. Ringworm of cattle, which is so prevalent on some farms, is an indication of neglect and indifference.

GLANDERS.

Glanders or farcy is an infectious disease due to a specific micro-organism, the *Bacillus mallei.* Pure cultures of the bacillus were first grown in 1882 by Löffler and Schütz and the etiological importance of the bacillus recognised by the former in 1886. It is essentially a disease of equines, and its existence is maintained by propagation in this species. Man is susceptible. The other domesticated animals, with the exception of dogs and cats, are immune, though dogs (especially old dogs) are somewhat resistant. In the horse the disease is as a rule of a chronic type; in the ass and mule it is generally much more acute.

The disease has occurred in Great Britain from early times, but considerable fluctuations have been observed in its yearly incidence as will be seen from the following figures :—

Year.	Outbreaks.	Horses attacked.
1874	522	636
1879	936	1367
1881	1012	1720
1886	776	1114
1892	1657	3001
1898	748	1385
1904	1529	2658

The large rises in 1881 and 1892 were probably due to the fact that epidemics of influenza were rife at those times (Hunting).

Though cases of glanders may be observed anywhere, outbreaks usually occur in cities and coal mines. In the country districts it is very rarely seen. In the United Kingdom it is practically absent from Ireland and Wales, and is rare in Scotland. The following table compiled from the annual reports of the Board of Agriculture and Fisheries and from the reports of the Department of Agriculture and Technical Instruction for Ireland show its distribution and yearly incidence :—

	1912	1913	1914	1915	1916	1917
England	163	157	93	42	38	21
Scotland	5	4	4	7	8	2
Wales	4	1	—	—	—	2
Ireland	—	1	—	1	1	—
London	86	90	52	15	8	8

In 1916 there were 1066 outbreaks in Great Britain and 8 in

Ireland. The number of outbreaks has gradually dropped from 854 in 1907 to 209 in 1911, and other figures are as just stated. Of large cities London has always been particularly badly affected, though the disease is now decreasing year by year. Hunting noted that during a period of 7 years 89 per cent. of the total outbreaks of glanders occurred in London and its vicinity.

As to seasonal incidence Hunting has remarked that in his experience more cases were seen from July to October than at any other time of the year, and that this was probably due to the fact that horses become more fatigued then than during the winter. The probability is that more cases tend to become clinical during the summer months than at other times.

Glanders is infrequently seen in young animals, since before maturity is reached they are not often brought into contact with affected animals. There has been a good deal of controversy as to the natural method of infection in the horse. Some have maintained that this occurs by inhalation owing to the fact that lesions in the lungs are rarely absent and in many cases exclusively present, but it is now generally admitted that ingestion is the common method. The disease is spread to healthy animals by contamination of food and drinking water with nasal or other discharges which contain the bacilli. Once the disease has entered a healthy stable and for a time remains undetected, it is easy to understand how the contagium may be unwittingly spread by the indiscriminate use of stalls, mangers, grooming tools (especially cloths and sponges), and by water pails and common watering-troughs. Public water-troughs in London at any rate may play a not unimportant part in disseminating glanders, but Hunting, while admitting that some cases may have arisen from their use, says that such instances must be few and far between and that the closing of them would do far more damage than would the possibility of glanders.

Imported Russian ponies sometimes introduce glanders into mines. In 1913, 6 outbreaks were discovered under the Mines Act and the 6 ponies concerned were imported from Russia.* Again in 1914 of 19 outbreaks in collieries 11 were caused by Russian ponies.†

Glanders is sometimes (more rarely than formerly) introduced among the carnivora of menageries by feeding with products containing glanders lesions. Cases are occasionally met with in human beings (knackers and grooms handling diseased animals), and in

* Cd., 7423, 1914.

† Cd., 8043, 1915.

them the disease is serious and frequently fatal. Infection is usually contracted by inoculation.

Using the term period of incubation to mean the time elapsing between infection and the moment at which visible lesions may be found on post-mortem examination, one may set down 10 to 15 days as being the average (Hunting). Feeding on small quantities of infective material is, however, followed by a rise in temperature in 3 or 4 days.

Preventive Measures.—Glanders is a scheduled disease, and for its control the local authorities are responsible. Since the year 1907, when the Glanders and Farcy Order was introduced, the number of outbreaks has shown a steady decline and one may expect that in a few years the disease will be of rare occurrence in Great Britain, if not totally eradicated. In discussing preventive measures it is essential to remember that glanders frequently occurs in a latent form, and it is only in a certain proportion of animals that the disease becomes clinically evident. It is thus seen that in the horse there is a marked tendency to natural recovery. This is further indicated by the fact that many animals which have reacted to the mallein test fail to do so later, and that from such animals glanders bacilli cannot be isolated after death. It is important, however, to notice that in some instances a horse which has ceased to react may still be glandered. With regard to the recovery of animals from glanders, the following facts in connection with outbreaks among the horses of the London County Council which occurred in 1900 and 1901 are of interest:—Of 63 reacting animals 13 became clinical cases and 9 were found to be glandered when killed later; 25 proved doubtful in final test and were slaughtered; 16 others ceased to react but were not destroyed. Thus of 63 reactors at least 16 ceased to react, and in these it was proved that recovery was real. An outbreak in 1895 in Paris described by Nocard showed that of 10,234 horses tested 2037 reacted and these were all latent cases. Of these 687 became clinical cases and 338 ceased to react. Some of the latter were examined after slaughter, and no glanders bacilli were recovered from any.

The hygienic measures to be adopted when a case of glanders has been detected in a stud are the early use of mallein to discover latent cases with the removal and destruction of all such as react. All contact animals must be tested and the term "contact" must include horses under the same ownership which may be in different localities or stables. Doubtful cases must be retested in a month, and indeed it is in reality essential to apply a second test to the entire stud a month or so after the initial test. Failure to detect

recently infected animals which may not react to a first test leads to a false sense of security and frequently to a second outbreak. Too much emphasis cannot be laid upon the fact that a stable cannot be considered to be free until a second test has failed to show any reactors. In the case of colliery animals or any stud into which a batch of newly purchased animals is to be introduced, a first testing which has revealed a reactor or a doubtful reactor should always be followed by a second testing after about six weeks, and before the newly purchased animals are mixed with the others. It need hardly be said that doubtful reactors should be kept rigidly isolated from the apparently healthy. Having removed both reactors and doubtful cases the premises must be thoroughly cleansed and disinfected (see Disinfection). Special attention should be paid to mangers, travisses, nose-bags, harness, especially bridles, and stall fastenings. Sponges, rubbers and the like should be burned. Mangers, buckets, drinking-troughs, carriage poles and shafts must receive careful attention. As the bacillus is readily destroyed by desiccation, &c., fresh air and light, especially direct sunlight, are valuable aids in the eradication of the disease. Horses coming from an infected stable should not drink from public troughs until all danger of infection is passed.

Animals which have presumably recovered from the disease, as shown by non-reaction to mallein for several months, possess no increased resistance to the *B. mallei* or its toxins (Nocard). A method of vaccination has, however, been introduced by Marxer* which depends upon the use of bacilli attenuated by urea and the resulting immunity is said to last about a year.

BOVINE CONTAGIOUS ABORTION.

Bovine Contagious Abortion (bovine epizootic abortion) is a contagious disease characterised by a chronic metritis due to a specific micro-organism, the *bacillus of contagious abortion,* or Bang's bacillus. The metritis is generally, but by no means in all cases, followed by abortion of the fœtus; and as a rule constitutional disturbance is very slight. The disease is strictly contagious, the causal organism being obligatory and incapable of multiplying outside the bodies of diseased animals. The source of infection therefore is always directly or indirectly a previous case. The disease, which has been in existence in the British Isles for many years, is now very widespread and probably the cause of greater economic loss to cattle breeders than any other. In this respect

* *Journn. Comp. Path.,* 1908, Vol. XXI., p. 269, Trans.

it would probably be safe to say that even tuberculosis takes a second place. In 1909 M'Fadyean and Stockman* had already proved the existence of the disease on 55 farms distributed over 36 counties, and at the present moment probably no single county in the British Isles is free.

The disease is naturally propagated by cattle but other animals are susceptible, and it has been conveyed experimentally with resulting abortion to mares, ewes, goats, bitches and sows. The possibility of infection of the human female is to be borne in mind, though no case of abortion due to this organism has hitherto been described. Judging by serum reactions male and non-pregnant animals are as susceptible as pregnant females, though no clinical symptoms of infection are shown. It occurs chiefly, but by no means exclusively, among young cows. It was at one time almost universally thought that infection took place in a passive manner *per vaginam* by contact with the contaminated urinary channel. The bull was also considered to be a frequent transmitter in a mechanical manner. Though bulls can be infected by injecting material into the preputial cavity and heifers can in the same way be infected *per vaginam,* it is highly probable that infection as a rule in natural cases occurs by ingestion of food and water contaminated with the specific organism.

Virulent material is practically confined to the uterus of infected cows and therefore, as Stockman has pointed out, gross infection of pastures or cow-sheds only takes place at or about the time of abortion. Bang's bacillus is, however, capable of prolonged extra-corporeal life, provided that it does not undergo desiccation. Thus on pastures and in cow byres it may remain virulent for a considerable time, according to Stockman nine months or more. The virus is abundant in uterine discharges, in the fœtal envelopes and in the aborted fœtus, and consequently food, water, &c., contaminated through these agencies may be the means of spreading the disease. According to Schrœder and Cotton† the discharge from an aborted cow is infective for 20 or 30 and in rare cases for 50 days. It can be laid down as probable that infective material has been got rid of from the genital organs at most two or three months after abortion. Aborted cows may retain the organisms in their milk for a long period (Zwick, Schrœder and Cotton) and thus act as carriers. Of 150 cows in a herd Schrœder and Cotton‡ found that 14 per cent. were passing abortion bacilli with their milk.

* *Journ. Comp. Path.,* 1909, Vol. XXII., p. 264, Abs.

† *Journ. Amer. Vet. Med. Assoc.,* Vol. L., p. 321.

‡ *Journ. Amer. Vet. Med. Assoc.,* Vol. L., p. 321.

Cooledge* in America found that 27 per cent. of the cattle on 7 farms were passing abortion bacilli in the milk. He further states that the milk may remain a carrier for years. The disease is thus as a rule introduced into healthy herds by an infected cow which at the time of abortion becomes an active centre of infection. From this centre infection may spread through the agencies above mentioned, and in addition may be conveyed to other animals by attendants, grooming tools, &c. The disease is enabled to establish itself in a herd owing to its insidious nature, and to the fact that the infectious nature of the trouble is not realised until some months later when several other pregnant animals abort. The mortality from the disease itself is nil, but deaths may follow as the result of such sequelæ as retention of placenta which commonly occurs.

It is not an easy matter to fix the period of incubation. Taking this as the period between the moment of infection and the act of abortion which, as before stated, does not always occur, it may be as short as a month or a good deal longer. In Bang's experiments in which cows were fed with culture or exudate, abortion occurred after one to two months.† According to Hutyra and Marek‡ abortion in the cow generally takes place in the fifth or sixth month of pregnancy.

Preventive Measures. — The Departmental Committee appointed in 1905 to report on the disease recommended compulsory notification of cases of abortion and veterinary inquiry to establish the existence of the disease, together with temporary isolation and restriction of movement of recently aborted cows and measures to prevent the importation of cases from abroad. Opinion to-day is rather at variance with these recommendations since the disease has become more widespread, and since more recent discoveries have pointed the way to methods of prevention which are unlikely to cause so much interference with cattle breeding.

Stockman, in his report to the Tenth International Congress, states: "Having regard to the facts that the disease prevails in an enormous number of dairy herds, and that a very high proportion of the animals are affected, state measures which are based on effective restrictions on the movement of infected animals would be ruinous to the business of farmers, while partial measures of the same kind are not worth the expenditure which would be incurred owing to administration. It is more than questionable, even assum-

* *Journ. Med. Res.*, Vol. XXXVII., No. 2, November, 1917, pp. 207-214, through *Vet. Rev.*, Vol. II., No. 2, May, 1918, p. 168.

† Hutyra and Marek, *Spec. Path.*, Vol. I., p. 741.

‡ Hutyra and Marek, *Spec. Path.*, Vol. I., p. 744.

ing their application to be practicable, if the severest restrictions on movement, comprising compulsory isolations for long periods of aborted animals and those still pregnant but known to be infected, would accomplish eradication, for we know that cows may become carriers of infection for a prolonged period during which the bacilli may be excreted in their milk."

The disease having appeared in a herd, much depends upon the construction and arrangement of buildings for the prevention of its spread. If isolation quarters are limited or entirely absent it is almost hopeless to expect that its spread among the herd will be prevented. However, every effort should be made in this direction.

Cows which have aborted, or which show signs of abortion, should be placed as far from the rest as possible. Suspected cows must be milked last, and separate grooming, feeding and drinking utensils supplied. Attendants must disinfect their hands and wash their boots after working among them.

Discharges, fœtus, membranes, and soiled litter must be burnt. The genital passage of aborted cows should be washed out at least once daily with a non-irritating antiseptic until fully a week after discharge has ceased. The tail and hindquarters should be washed with a disinfectant at least twice daily. Stalled cows should have their tails tied so as to keep them clear from the fæces channel when they lie down, and to prevent cows swishing them about. After each cleansing of the fæces channel it should be flushed out with plenty of water; this is easily accomplished without flooding the liquid manure tank if a two-way pass is used (see p. 71). Newly purchased cows should, if possible, be isolated until they have calved clear of suspicion.

Washing of the penis and prepuce of the bull should be practised if the animal belongs to an infected herd or if it is used by neighbours when the disease is suspected to be in the vicinity.

One attack is followed by immunity. The majority of cows do not abort a second time, and it is still more rare for a third abortion to occur in the same animal. The disease in the herd thus tends to wear itself out. In addition to the methods of isolation and disinfection already described, measures of vaccination have been introduced for the prevention and control of the disease, and these have met with a very considerable amount of success. Two kinds of vaccine have been tried in Great Britain, designated Anti-abortion A. (consisting of living bacilli) and Anti-abortion B. (consisting of dead bacilli). One dose of the former is given and the animal is not put to the bull until at least two months after

inoculation. The latter was used for pregnant animals, one dose being given monthly until the sixth month. It was soon found, however, that little good was derived from the use of Anti-abortion B., and this was therefore discontinued. Stockman gives certain statistics* which show beyond any possibility of error the very great advantages accruing from the use of the living vaccine. Thus of 265 untreated animals in badly infected herds 38 per cent. aborted, while of 493 vaccinated animals the number which aborted was only 6.5 per cent. This method of vaccination has been put into practice on a fairly considerable scale in Oxfordshire, and the following statistics covering the period 1914-1916 show the results with 1289 animals; of these 5.7 per cent. aborted against 20.7 per cent. untreated controls. In 1913 30 per cent. aborted in this county.†

ENZOOTIC OVINE ABORTION.

The causal organism of this disease is a motile vibrio (M'Fadyean and Stockman). There is a certain amount of evidence leading to the belief that it may exist as a saprophyte outside the body. At present the disease may be said to be enzootic rather than epizootic. As pointed out by Stockman, this is owing to the fact that the cross trade in sheep is not carried on to the same extent as with cattle, and that lambing is confined to a more definite period of the year. Abortion usually follows infection much earlier than is the case with bovines; it may occur very soon after infection or it may be delayed for several weeks (Stockman). Though the vibrio is the specific organism of ovine abortion it may, and sometimes does, cause abortion in cows. Indeed, recent researches in America by Theobald Smith and collaborators have shown that a similar or identical vibrio was present alone in nearly 24 per cent. of 109 cases of bovine abortion. The disease is manifest usually within a few weeks after tupping has taken place. Stockman gives the losses in infected flocks as from 10 to 40 per cent.‡ Infection may take place either *per os* or *per vaginum*, but it hardly appears to be certain which is the more common natural method. Stockman has shown that ewes can carry infection *in utero* for considerable periods between pregnancies. If this view is correct, the ram is probably one of the chief disseminators.§

* Report to Tenth International Veterinary Congress.

† *Vet. Rev.*, 1917, Vol. I., p. 169.

‡ *Annual Report*, C.V.O., Board of Agric., 1913, Cd, 7423.

§ *Annual Report*, 1914, Cd, 8043.

Stockman therefore doubts "whether the infection in connection with ovine abortion is in reality kept up mainly owing to a saprophytic existence on the part of the vibrio."

Preventive Measures.—The most certain method of preventing the spread of the disease is to make it compulsory that breeding stock is sold only on a guarantee that the flock is free from infection.

EQUINE ABORTION.

This is a contagious disease due to a specific organism belonging to the para-typhoid group and called the *Bacillus of equine abortion* or *Bacillus abortivo-equinus*. Though some observers abroad (Ostertag and others) have considered that streptococci are the real cause, the researches of M'Fadyean and Edwards* have shown that the paratyphoid bacillus mentioned is responsible for a large proportion of cases of abortion in this country, and for some cases of joint-ill occurring in foals shortly after birth. The same organism had previously been isolated in the course of outbreaks by other workers abroad (Smith and Kilborne, de Jong, &c.). The disease has probably existed in this country as an enzootic since an early date, but though still present and the cause of considerable losses in parts of Great Britain it has not attained the same ubiquity as bovine abortion owing to the fact that traffic in mares is much less than with cows. Though natural cases of infection by this organism only appear to occur in the mare and foal, abortion has been produced by inoculation into the pregnant cow, ewe, goat and sow. Outbreaks have been described in donkey studs (Clive Webb)† and the same organism has been isolated from one such outbreak by Good and Corbett in North America. According to Desoubry‡ abortion may occur at almost any period of gestation. The natural method of infection is probably by ingestion of food or water contaminated with virulent discharge, though it should be remembered that the stallion may play a part in the spread of the disease. De Jong was successful in infecting one mare by feeding with artificial culture mixed with food, abortion occurring in this animal on the twelfth day. The period of incubation has been fixed at about 15 days. The disease is spread from one part of the country to another in the same way as bovine abortion, *i.e.*, by the sale of recently aborted mares or infected pregnant mares which are apparently healthy. It is not certainly known how long the organism can

* *Journ. Comp. Path.*, 1917, Vol. XXX., p. 331.

† *Journ. Comp. Path.*, 1909, Vol. XXII., p. 289.

‡ *Journ. Comp. Path.*, 1909, Vol. XXII., p. 154, Trans.

remain alive outside the body. The mortality is variable, and such deaths as occur are due to septic infection following retention of the placenta.

Preventive Measures. — One attack is said to produce immunity and a second abortion in the same animal is said to be rare. Preventive measures should follow in principle those laid down for bovine abortion. Newly purchased mares should be isolated and separate attendants provided. Should abortion occur in a stud strict isolation and disinfection are essential for the prevention of its spread. Aborted mares should not be again used for breeding for at least two months, and then only when treatment by uterine washings has been practised (see Joint-Ill).

JOINT - ILL.

Joint-Ill (navel ill) is a pyæmic affection of newly-born animals. Infection frequently occurs in foals but also in calves, lambs and pigs. The disease is very widespread both in Europe and on the American Continent, and is probably not confined to any particular breed or strain of animal. Various bacteria have been associated at times by different authors with joint-ill, namely, streptococci, staphylococci, pasteurellæ, and colon bacilli. Within recent years however, the confusion which previously existed regarding the etiology of joint-ill has been to a great extent removed by the researches of Polajkow, Dassonville and Rivière, Good and Smith, Schofield, and by M'Fadyean and Edwards* in Great Britain. The latter state that at least a large proportion of cases of equine abortion and some cases of joint-ill occurring in this country are caused by the *bacillus abortivo-equinus* previously described by Smith and Kilborne, de Jong, Good and Corbett and others. It is in those cases in which joint-ill in the foal is associated with abortion in the mare that the *bacillus abortivo-equinus* is the chief offender. M'Fadyean and Edwards succeeded in isolating this organism from foals; from six of these the bacillus was recovered from the joints, and in three of the latter cases the foal was born dead and free from any sign of joint disease. It therefore appears most probable that in some cases joint-ill is intimately associated as regards its etiology with abortion in mares. Infection would, therefore, be prenatal and of the foals some are born dead, and those which survive are especially liable to suffer from joint affections. In a proportion of cases there is at the same time suppuration at the umbilicus. This may be due to the common pyogenic micrococci, but it is also quite

* *Journ. Comp. Path.*, 1917, Vol. XXX., p. 321.

likely that some at any rate are due to the *bacillus abortivo-equinus,* since of 172 cases of joint-ill described by M'Fadyean and Edwards not less than 87 showed suppuration of the navel.

On account of the high mortality (probably not less than 80 per cent.) the disease is an extremely serious one.

Further light has been shed upon the subject by more recent researches of M'Fadyean and Edwards.* Of 72 cases examined by them 62·5 per cent. were due to streptococci, the remainder being due to coliform and other organisms. In the great majority of these cases abortion was not coexistent.

From the foregoing it seems probable that infection in joint-ill may occur either before or shortly after birth, but that in most cases in which the disease is contracted before birth the cause is the *bacillus abortivo-equinus.* It is certain that the disease is often seen under the best of hygienic conditions and is often absent from the most objectionable buildings and surroundings. Inbreeding has been considered to be a not unimportant predisposing factor, though it is certain that the disease is frequently seen when inbreeding has not occurred.

Preventive Measures. — When joint-ill is associated with abortion, preventive measures must be directed toward the suppression of the latter disease (see Equine and Bovine Abortion). A protective serum (prepared by hyperimmunising horses to *b. abortivo-equinus*) was issued by M'Fadyean and Edwards and was said to have given encouraging results in practice. More recently, however, in view of the importance of a streptococcus as the etiological factor in those cases in which infection has occurred post partum, an anti-streptococcic serum has been tried by the same observers but unfortunately without much success. At the present time, therefore, one can only confine one's attention to the umbilical region, using for this purpose sublimate lotions or pure carbolic acid. In addition one should follow the ordinary dictates of hygiene, including cleanliness of the foal's surroundings, &c.

WHITE SCOUR.

White scour is an acute disease of sucking animals, chiefly calves, though sometimes of foals, lambs and pigs. A persistent diarrhœa with fæces of a characteristic yellowish colour is the outstanding feature of the disease. Pneumonia with formation of abscess cavities in the lungs and arthritis are lesions sometimes superadded. The distribution of white scour is very general on the European

* *Journ. Comp. Path.,* 1919, Vol. XXXII., p. 425.

Continent and in the United Kingdom. It is essentially a disease of unweaned animals and they may be attacked within 24 to 48 hours after birth, and in any case the disease generally appears within the first week of life.

The researches of Jensen* in Denmark have been chiefly instrumental in clearing up doubts regarding the cause of the disease. In 1893 Jensen reported that of 211 calves on one large farm 122 died of white scour during twelve months, and of 189 calves on another farm 142 died. From many of these dead calves Jensen isolated bacteria of the colon type which were very virulent and capable of reproducing the disease in healthy calves in small doses *per os.* The fæces themselves were infective in small doses in the same way. Since then other bacteria have been incriminated, namely, *paracolon* (Poels), *Bacillus aerogenes* and *Bacillus proteus* (Jensen). Lesage and Delmer, and Nocard† considered that white scour was due to a pasteurella which gained access to the body during or after birth. The bulk of the evidence is against this and in favour of the view that the immense majority of cases of white scour are due to bacteria of the colon group, and that the infection takes place *per os.* The disease in other animals is produced by similar types of bacteria, and it is said that the disease may be conveyed to the young of other species by placing an infected calf among them. The disease is not due directly to dietetic errors, *e.g.,* feeding animals immediately after birth on boiled milk, *i.e.,* withholding of the colostral milk. Such errors may act as predisposing causes and especially perhaps in the first few cases, from which the disease spreads to others through the medium of virulent fæces until outbreaks may reach the dimensions of small enzootics. Such virulent fæces may soil the udders of cows, hands of attendants, feeding vessels, &c., or spread may occur through the animals licking each other. The rate of mortality is very high, probably from 80 to 90 per cent., and the course of the disease is usually short.

PREVENTIVE MEASURES.—Strict attention should be paid to hygienic requirements in connection with the housing of the cow both before and after calving. Calving houses must be built so that they are capable of being efficiently cleansed and disinfected. The cow's vulva, thighs and udder may be washed daily for some days before she calves with a non-irritating antiseptic and kept as clean as possible after calving. Nocard, who believed in umbilical infection, attached great importance to ligature and subsequent

* *Journ. Comp. Path.,* 1905, Vol. XVIII., p. 345, Trans.

† *Journ. Comp. Path.,* 1902, Vol. XV., p. 174, Abs.

dressing of the umbilical cord. The above measures are intended to minimise the chances of infection occurring through the umbilicus, this being the view held by some observers regarding the nature of the disease. In any case they can hardly be considered superfluous even when one holds the view that infection is chiefly spread by infected calves after birth. Great attention should be paid to the feeding of calves during the first week or so after birth; they should, if possible, get the colostral milk. Attendants should see that their hands and feeding vessels are kept scrupulously clean. Dry sanitary quarters with an abundance of light and fresh air are desirable factors in the prevention of this disease. Should a case of white scour occur, rigid isolation and measures for preventing spread through the medium of infected excretions must be enforced.

Very efficient antisera against the disease have been produced by Jensen by injecting horses intravenously at intervals of 10 to 12 days with increasing doses of cultures of several different strains of colon and paracolon bacilli. The serum, which is thus polyvalent, is injected subcutaneously in calves in doses of 20 cc. The serum is so efficient according to Jensen that it is hardly necessary even to pay much attention to hygienic precautions and on many farms the serum is said to have reduced fatalities to zero even when the previous mortality was 100 per cent. It is also said to have some curative action, but not constant.

INFLUENZA.

Influenza (horse distemper, pink eye, typhoid fever, epizootic gastro-enteritis) is an acute infectious disease solely affecting equine animals. The human disease of the same name is in general believed to be different. The symptoms shown by different animals in an outbreak are often diverse, and in consequence many observers have contended that the disease is not a morbid entity but that in reality several diseases are included under the term influenza. It is generally, however, characterised by fever accompanied by catarrhal symptoms, depression, and marked muscular weakness. It is not rarely followed by serious sequelæ, *e.g.*, pneumonia.

The actual cause of the disease is at present still uncertain. Several different species of organisms have been considered by observers to bear an etiological relationship to influenza. According to Lignières* the primary cause is an organism of the pasteurella group which, however, as a rule merely serves to pave

* Lignières, *Journ. Comp. Path.*, 1889 (Trans.), Vol II.

the way for the streptococcus of strangles, which is in part at least responsible for the lesions and for such sequelæ as pneumonia or pleurisy which occasionally follow an attack of influenza. Schütz considered influenza to be due to a diplococcus, which by other observers (Lignières, &c.) was considered to be at least closely related to the streptococcus of strangles. Inasmuch, however, as it has been shown that the disease can be transmitted experimentally to healthy horses by means of blood which has been passed through a bacterial filter, it seems likely that the cause is an ultra-visible one.

Though influenza is a widespread disease a larger proportion of outbreaks is seen in cities, and especially in such places as horse repositories, dealers' stables, &c.

Outbreaks are usually of an enzootic nature, and once introduced into a stable the disease spreads very rapidly. Isolated cases do, however, occur. The disease has no predilection for young horses except so far that such when brought in from the country undergo a sudden and complete change of life which would in itself render them more receptive to pathogenic organisms. The disease is spread through the agency of the secretions and excretions, and these are said to be especially infectious during the early stages and at the height of the attack. Infection may occur by ingestion of contaminated food, drinking water, &c., though the possibility that it may occur *via* the respiratory organs cannot be excluded. Infection may thus be direct as from horse to horse or by any of the indirect means described under strangles such as by feeding utensils, broken fodder, grooming tools, water-troughs, and stable attendants. It is also spread by contaminated horse boxes on railways and by ships. An animal which is convalescent has also to be looked upon as dangerous. A fact conclusively established by clinical and other evidence is that apparently healthy stallions, though not dangerous in the usual sense of the term, are at times capable of transmitting the disease by coitus. They may thus act as " carriers " of the infection for months. Instances of this method of transmission have been noted by Pottie,* Caulton Reeks,† &c. In some of these cases the semen was found to be virulent on inoculation even after it had been passed through a bacterial filter. Mares infected in this way may transmit the disease to other equines by contact.

The period of incubation is from 3 to 7 days. Most cases recover quickly, but sequelæ may supervene and the mortality may reach 15 per cent. (Dieckerhoff). Whether one attack confers any

* Pottie, *Journ. Comp. Path.*, 1888, Vol. I.

† Caulton Reeks, *Journ. Comp. Path.*, 1901, Vol. XIV.

degree of immunity is not definitely known. Immunity probably does develop, but is not serviceable for any considerable time.

PREVENTIVE MEASURES.—If influenza appears in a town notice of the fact should be made in the public press by the local authority in order that horse-keepers may take precautionary measures. Such measures are, closing the stable and stable yard to strange horses or, if any must enter the yard, at least forbidding them the use of the yard-trough. Carters should be supplied with pails from which horses should be watered both when at work and in the stable. The use of sponges and cloths should be prohibited, and brushes and other grooming tools must be kept clean and frequently soaked in disinfectant.

If the disease appears in a stud the temperatures of all horses should be taken every morning before they leave for work. This is a very important precaution as it enables infected animals to be detected early and removed immediately from the main stable.

Isolation of infected animals is imperative if the spread of the disease is to be prevented, and stalls that have harboured sick animals must be thoroughly disinfected and left vacant for as long as possible. It is important that all the litter, whether soiled or not, be removed; partially soiled litter must not be used for neighbouring animals on the score of economy. The virus is said to live for a long time in damp, badly-ventilated stables, but soon loses its virulence by exposure to fresh air and sunlight.

CONTAGIOUS EQUINE PNEUMONIA.

This pneumonia of the horse is characterised by a marked tendency of the involved lung to undergo necrosis followed by gangrene (necrotic pneumonia). It may or may not be accompanied by pleurisy. While some consider contagious equine pneumonia to be a distinct disease, other observers (Lignières, Hutyra and Marek) look upon it as being no more than a complication (pectoral form) of influenza. Miessner* describes two diseases (1) Lung disease (Brüstseuche) or pectoral influenza and (2) Infectious bronchitis or bronchopneumonia, the latter being more chronic and the alterations being primarily bronchial. The direct cause is uncertain. Lignières considers it to be a pasteurella with which is often associated as a secondary invader the streptococcus of strangles (see Influenza). Schütz regards as the cause a small ovoid bacterium which he has been able to isolate from cases. Horses are the only animals affected. The disease is wide-

* *Epizootics and their Control in War,* Miessner, Trans. by Liebold, 1917.

spread and especially to be found in large cities. It caused considerable havoc among horses of the British Army during the war. Predisposing causes are any conditions which lower the vitality (see influenza, strangles) and especially to be noted in young horses are want of condition, fast work and exhaustion. Hunting considered that alterations of temperature are very productive of pneumonia, and in support of this mentions that pit ponies do not become affected owing to the fact that they are not subjected to much variation of temperature. It is thus essentially a disease of young horses, older animals being comparatively immune to the causes predisposing. F. Smith* does not incline to the view that the disease is contagious, and considers that the causal organisms are probably present in healthy horses, but do not invade the body until the vitality is lowered. It appears to be undoubted that a larger number of cases, and cases of greater severity, occur in winter than in summer (F. Smith). Infection is generally supposed to occur by inhalation. Infection may be spread not only by direct contact but also indirectly by attendants' hands and clothes, by grooming utensils, sponges, &c., and by bedding contaminated with nasal discharge. According to Dieckerhoff the period of incubation is 5 to 10 days, and the mortality 15 per cent. In 7 outbreaks affecting 570 animals described by Lignières the mortality was 8.8 per cent. F. Smith† found a mortality of nearly 18 per cent. in a number of cases of pneumonia, some of which were complicated with pleurisy.

One attack is considered to furnish a certain degree of immunity, and it is exceptional for animals to be attacked twice at a short interval.

The Preventive Measures to be adopted in controlling the disease are essentially the same as those mentioned in the case of strangles and influenza.

It is not to be supposed that because the diseases strangles, influenza and pneumonia have been described under separate headings they do not co-exist. Pneumonia is often seen as a sequel or complication of both strangles and influenza and differential diagnosis may be difficult.

STRANGLES.

Strangles is an infectious febrile disease associated with an inflammatory condition of the upper air passages and usually accom-

* *Journn. Comp. Path.*, 1897, Vol. X.

† *Journ. Comp. Path.*, 1897, Vol. X.

panied by abscess formation in the submaxillary lymphatic glands, and at times in any other part of the body. It is considered by most observers to be caused by the *Streptococcus equi* discovered in 1888 by Schütz, though some have held that an ultravisible virus is the real cause, the streptococcus being a secondary invader. Infection is restricted to horses, asses and mules, though the last named animals are more resistant. The other domesticated animals are not susceptible. It is chiefly a disease of young horses but animals of any age may be attacked. Seventy per cent. of cases occur in horses under 5 years of age and only about 10 per cent. in horses over 15 years of age.* Healthy aged horses can resist large doses of culture or abscess discharge. Todd failed to infect such horses by smearing virulent material on the nostrils, by feeding with similar material, and in one case by actually rubbing culture into the previously scarified mucous membrane of the nose. There is no special seasonal incidence, though, according to Hutyra and Marek, outbreaks are more commonly seen in the spring. Predisposing causes are any conditions which tend to lower the vitality, *e.g.*, bad weather, long train journeys, long voyages, fatigue, recent illness, and, especially in young horses, any sudden change, *e.g.*, of food, environment, &c.

The disease has been known since early times and is more or less universally distributed throughout the United Kingdom. It is usually supposed to be contracted by ingestion of food or water contaminated with nasal or other discharge from a pre-existing or accompanying case, but the spread is also facilitated at times by attendants' clothes and hands, harness, bedding, &c. Want of surgical cleanliness such as the careless use of a scalpel after opening an abscess has been known to spread the disease, and notably so at castration. Infection has been known to pass from dam to fœtus,† from stallion to mare during coitus, and also from foal to mare during sucking. It is improbable that the streptococcus multiplies to any great extent in nature (as Schütz believed) and the organism is generally regarded as being obligatory. Outbreaks are thus never sporadic, the disease being introduced into a stud in the first place by an infected or may be convalescent animal. There is evidence that the streptococcus may be present for long periods in the nasal cavities of horses which have recovered from an attack, and such animals may act as "carriers." In this connection it is important to note that it has been proved by clinical evidence that cases of simple catarrh or so-called "catarrhal fever" are in reality

* Todd, *Journ. Comp. Path.*, 1910, Vol. XXIII.

† Choisy and Nocard, *Journ. Comp. Path.*, 1888, Trans., Vol. I.

cases of strangles. Such atypical forms have been known to cause outbreaks of typical strangles among young horses; three such outbreaks have been described by Bigoteau.*

The period of incubation is about 3 to 8 days. The mortality is not high generally, but the type and virulence of the disease vary considerably. Cases are often more malignant and fatalities higher in young foals. Typical cases generally last 2 to 4 weeks and end in recovery. The streptococcus equi is destroyed by sunlight in 8 hours and by desiccation in about 3 weeks (Nocard and Leclainche), while freezing for 2 days does not destroy it (Todd).

Preventive Measures.—Isolation of infected animals and disinfection of contact materials are the essential methods by which the spread of strangles is prevented in a stud. Sick horses should be removed entirely from the healthy and housed in boxes or elsewhere away from the main stable. Separate attendants should be provided and feeding utensils, buckets and other stable gear must not be interchangeable. A thorough cleansing and disinfection of stalls vacated by sick horses and the mangers therein must be carried out before other animals make use of them. The opening of abscesses in the common stable or in the yard is a dangerous practice unless straw or other material is used to catch the discharge, which should then be carefully destroyed. If, as is the case in many stables, there is but one attendant whose duties are to nurse the sick and prepare the food for the healthy and feed them, he must be instructed to attend to the sick animals when his other work is done and on no account to omit to wash his hands and his boots after fomenting an abscess or grooming a sick horse. Overalls should be provided for use when tending sick horses. The stableman is undoubtedly the chief intermediate carrier of strangles infection. Horses which have recovered from strangles should not be allowed to mix with the other horses in the stable for 3 or 4 weeks after they have returned to work. Horses which have so far advanced in convalescence as to be put to light work are not necessarily free from infection. All new purchases, and especially young horses, should be quarantined for at least 15 days before being brought into contact with other animals. Cases of "catarrh" should be isolated until some time after the symptoms have subsided. If a common water-trough is made use of it is advisable to close it temporarily. Under no circumstances should strange horses be allowed to drink from a stable yard-trough.

One attack confers a certain degree of immunity. This, however, is in some cases insufficient to prevent further reappearance

* *Journ. Comp. Path.*, 1893, Trans., Vol. VI.

of the disease at later periods. Animals may thus pass through several attacks but after the first these are often milder and tend to assume the atypical (catarrhal fever) form. Attempts have been made to vaccinate animals by the use of both living and dead cultures applied subcutaneously and intravenously. Serum from hyperimmunised animals has been used both as a prophylactic and curative agent. Opinions vary considerably as to the efficacy of these measures. It seems that large doses of a good serum injected intravenously may be beneficial in the treatment of the more malignant (cutaneous, &c.) forms of the disease.

PURPURA HÆMORRHAGICA.

Purpura (petechial fever) is a low fever associated with the formation of multiple larger or smaller hæmorrhagic centres in the skin and subcutaneous tissues, in the respiratory and alimentary mucous membrane as well as in other organs. Though usually described as a microbial disease no causal organism has been demonstrated, nor can the disease be produced experimentally. Purpura is generally regarded as a secondary disease, as following upon or associated with any disease or condition which lowers the vitality of the animal. Some even doubt that it occurs as a primary disease, but with the author at least no such doubt exists; at any rate it may and frequently does manifest itself as the primary indication that the animal is ill. Though generally considered to be associated either with a debilitating disease or with an unhygienic environment or a combination of both, purpura may appear when these conditions are absent. Nevertheless, this disease is to be regarded as one which comes within the scope of the hygienist. The author has seen it occur as a "primary" disease in a single horse stable, if such it could be called, that abutted on a particularly offensive earth closet while, on the other hand, purpura fails to become evident under other conditions no less conducive. Thus, on a transport plying between the United States and South Africa during the South African War in which in four voyages 4369 horses were carried under conditions which would not have passed muster in the late war, not more than 6 or 8 cases were observed. As a rule cases are isolated, and though some hold that the disease is infectious and that it may pass from one animal to another in the same stable there does not seem to be any definite evidence that this is so. If such were the case one might have expected that under transport conditions, such as those with which we have been associated, the disease would have shown a tendency to spread

from one animal to another. That such was not the case is strong presumptive evidence as to the non-contagious nature of the condition. The disease is essentially one of the horse but it has been observed in cattle by Cadeac* and others on the Continent, and more recently Lissot† has recorded three cases of what he had reason to believe was the same disease occurring in cows. Purpura is more commonly observed in young horses. Of 17 cases of which accurate notes were taken by Zschokke‡ there were 12 deaths, and the disease always appeared during or immediately following some disease of the respiratory organs, *e.g.*, strangles. The average duration of cases was 16½ days. Though not invariably fatal, the rate of mortality is always high.

Preventive Measures. — These should be directed toward keeping horses under hygienic conditions, such as good ventilation, drainage, light, &c. Over-fatigue, under-feeding and general bad stable management must be avoided, and any other conditions that may lower the normal vitality of the animal.

Convalescent patients should not be put to work too soon after an illness, and this is especially necessary after such debilitating affections as influenza, strangles or pneumonia.

CATTLE PLAGUE.

Cattle plague (rinderpest, bovine typhus) is a contagious disease chiefly affecting cattle and occasionally sheep, goats and pigs, caused by an ultravisible virus. It is indigenous in certain parts of Asia, and has in the past caused considerable ravages in Africa. It has been responsible for outbreaks in this country but inasmuch as the last occurred in 1877 it need be given little consideration in this work. It was eradicated from the United Kingdom by the method of slaughtering out, and should the disease at any time in the future be introduced, the same methods would be adopted, and judging from previous history with success. The chief source of danger would be the affected animals, but the disease also spreads by mediate methods, *e.g.*, by infected food, water, &c., as well as by the agency of human beings. In countries where the disease occurs in the form of epidemics, these vary considerably in virulence, the latter becoming less owing to those which recover acquiring immunity. A very efficient anti-serum has been widely used in outbreaks.

* *System. Vet. Med.*, W. Hoare, Vol. I., p. 887, 1913.

† *Rec. Med. Vet.*, Vol. XIII.

‡ Zschokke, *Journ. Comp. Path.*, 1898, Trans., Vol. XI.

CONTAGIOUS BOVINE PLEURO-PNEUMONIA.

Contagious bovine pleuro-pneumonia (lung plague) is an acute or sub-acute, though frequently somewhat insidious, disease affecting only bovine animals and caused by an exceedingly minute organism discovered by Nocard and Roux in 1898, and which can only be seen under a magnification of about 2000 diameters. The disease is characterised by lung lesions of a peculiar type and by a fibrinous exudative pleurisy, though the latter lesions are secondary to the pulmonary involvement and may not always be present.

Pleuro-Pneumonia was at one time a very widespread disease in the United Kingdom and abroad. It was first introduced, it is thought from Holland, about 1840 and its very considerable ravages may be gathered from the statement that in 1873 there were 2711 outbreaks involving 8817 animals, in 1874 3262 outbreaks involving 9225 animals, and in 1877 2007 outbreaks involving 6683 animals. During the 25 years ending 1894 103,000 animals died or were slaughtered in the United Kingdom as the result of the disease.* In 1873 slaughter of diseased animals was first made compulsory, but until 1888 for certain reasons little real progress was made in the extermination of the disease. In 1888, however, the principle of compulsory slaughter of affected animals and all incontacts was put into practice, the result being that by 1897 the disease had been stamped out of country districts and was only present in the east end of London. The disease has been non-existent in the British Isles since 1899.

The causal organism being obligatory, contagion can only spread from animal to animal. The method of infection is by inhalation of infected particles contained in the expired air of diseased subjects, and transmission can thus readily take place in animals which are stalled close together. The period of incubation is somewhat lengthy and is generally considered to be about 6 weeks. A rise of temperature occurs earlier than this however, and Nocard and Roux placed the period of incubation after inhalation at 12 to 16 days. The virus can remain alive for a certain time outside the body, *e.g.*, Germont and Loir found that the virus kept in glass tubes in the dark and at laboratory temperature could retain its activity for 15 to 20 days.

Preventive Measures.—Outbreaks in the British Isles would always be dealt with by ruthless stamping out methods. All affected animals should be slaughtered, together with any which

* Report, C.V.O., Bd. of Agric., 1895.

have been in contact with contagion. Methods of inoculation, such as have been extensively practised both in this country and abroad, are useless owing to the fact that inoculation can never render less dangerous as a disseminator an animal which is affected with chronic lung lesions and which is to all appearances in good health. All animals slaughtered should be disposed of by cremation or burial according to the recognised method (see p. 227), and all buildings vacated should be disinfected and left clear of cattle for a period of a month or so.

FOOT-AND-MOUTH DISEASE.

Foot-and-mouth disease (aphthous fever) is an acute and very highly infectious disease characterised by the production of vesicles in various parts of the body, but most frequently on the mouth and feet. Cattle are especially affected and to a less extent sheep, pigs and goats. Horses, dogs and cats have been known to become infected, but cases are rare. De Jong* has recorded the occurrence of the disease in three foals which were turned out to graze with affected cattle. Man is susceptible, children being especially liable to infection through drinking milk from cows having vesicles on their teats, and in them the condition may be fatal.

The disease is produced by an ultravisible virus demonstrated by Löffler and Frosch (1897 to 1900). It is contained in the lymph of vesicles, in the saliva, in the milk, and during the febrile period in the blood.

Foot-and-mouth disease was first recorded as existing in Great Britain in 1839, and was present continuously from that date until 1886, with the exception of a few months' freedom at the end of 1879. Probably not less than 7,000,000 animals were attacked during this period. Since 1892 the importation of cloven-hoofed animals from abroad has been prohibited. From the report of the Departmental Committee appointed in 1911, it appeared that " in 10 out of the 21 years from 1892 to the present time the disease has existed in Great Britain, the total number of outbreaks in that period being 158, but of these 133 occurred during the first 10 years and only 25 during the last 11 years." The disease again cropped up in 1892, when there were 95 outbreaks involving 4767 animals. In 1893 there were only 2 and in 1894 3 outbreaks, and the disease was then absent until 1900 when 21 outbreaks were recorded. The country was free for 6 years previous to 1908 when the disease appeared in Edinburgh, and from that date it

* *Journ. Comp. Path.*, 1912, Vol. XXV., p. 153, Abs.

has been present with the exception of the years 1909 and 1917. In 1912 there were 83 outbreaks.

It will thus be noted that the striking fact with regard to foot-and-mouth disease in this country is its great liability to appear in spite of the stringent regulations which are in operation to prevent its introduction. Another point which is common to nearly all outbreaks in this country, and in any country to which the disease is normally exotic, is that it is often impossible to say how the contagium has been introduced. It can certainly be said to be by mediate methods, and it has been remarked that outbreaks here usually coincide with a rise in the prevalence of the disease in continental countries. The Departmental Committee appointed in 1911 gave special consideration to the means by which the disease is imported into the United Kingdom. They considered that " any imports such as hides, &c., which may have formed part of an infected animal or been exposed to infection, and other goods such as grain, food-stuffs, &c., which may have been in contact with them must be considered dangerous if such articles are subsequently brought into contact with susceptible animals in this country." They observed that the risk was greater with certain articles, especially hay and straw, milk and milk products, hides and skins, carcases of calves in skins, heads and feet, vaccine seed lymph, hoofs, horns, bone and other animal offals, persons and their clothing. The importation of hay and straw from all other countries, except those scheduled as being free from the disease, is now prohibited, but hay and straw used as packing is a likely mode of introduction, especially as such material usually finds its way into manure. The chief danger attaching to milk is the possible infection of pigs. From hides and skins the danger is that such may contaminate feeding-stuffs either in the ship or in railway trucks, &c., or through the clothing of those unloading the ship. The possibility of sea-crossing birds carrying infection from the Continent to this country on their feet, or in their intestines after feeding on infected animals, is recognised. The disease spreads very rapidly once its introduction has taken place, chiefly by contact between animals, the virus probably entering abrasions, *e.g.*, of the intestinal tract.

Mediate methods are very largely responsible for the spread of foot-and-mouth disease, and these may be many and varied. The infection may be carried on the hands, clothes and boots of persons, by litter, dung or ships' fittings, birds, dogs, and other animals. The contagium is not air borne, except in so far that a high wind may blow saliva a very considerable distance. Water-troughs or ponds from which diseased animals have drunk are dangerous distributors,

and a running stream may pass infection from one field to another by carrying contaminated chaff or straw.*

The period of incubation is from 1 to 10 days, generally 2 to 5 days. The rate of mortality which may be expected from this disease is of little interest to the hygienist in this country, since all infected and contact animals are slaughtered. Bang† pointed out that the mortality in adults may be barely ½ per cent. If, as occasionally happens, the prevailing type of disease is of a more virulent nature, the mortality may be much higher than this. For unweaned stock the mortality is always high, but in older animals as a rule symptoms have disappeared within ten days or a fortnight. The disease is a serious one owing to its extremely infectious nature and to the great economic loss resulting from trade disturbance, abortion, diminished secretion of milk and falling off in condition.

According to Schütz the saliva of infected cattle is no longer dangerous for other animals after 10 days. Zschokke,‡ however, states that the virus may remain latent for a considerable time in closed clefts in the horn of the hoof. He has noted outbreaks arise after the horn of the claws of such cattle had been pared. These cattle had shown symptoms of the disease three or four months previously and no other source of contagion had been possible.

A Commission on the subject in Berlin which reported in 1897 and 1898 found the virus to be active after 14 days' exposure in an ice chest. Its infective power was uncertain after 3 weeks, though some samples conveyed the disease up to 8 or 9 weeks. They further found that diluted lymph kept on ice was active up to 4 months. The virus was killed by 24 hours' desiccation at summer temperature, by half an hour's exposure to heat at 70° C, or by one hour at 60° C. According to Zschokke the virus when sealed in glass tubes in sterile conditions and protected from light may remain alive for 3 to 4 months. Evidence derived from the Edinburgh attack of 1908 also indicated that the virus might remain active outside the body in certain circumstances for at least 3½ months.

Preventive Measures.—Strict portal inspection and adherence to the Orders restricting importation of cattle and fodder are the most effective methods of preventing the appearance of the disease in this country. Should it appear, early detection and notification

* *Annual Report,* C.V.O., 1912, Cd, 6737-1.

† *Journ. Comp. Path.,* 1912, Vol. XXV., p. 1., Trans.

‡ *Journ. Comp. Path.,* 1912, Vol. XXV., p. 355, Abs.

are essential for successful combative measures to be applied with as small interference with trade as possible. The premises containing the suspected animals must be immediately isolated, and both animals and people prevented from either entering or leaving. Confirmation of the suspicion is followed by slaughter of all animals especially susceptible, that is, cattle, sheep, goats and swine. The slaughtering out of animals which have not been in contact with those not immediately exposed to infection is a matter for decision according to circumstances. Rigid movement restriction orders are enforced within an area having a radius of 15 miles or so from the infected premises.

Ships, wagons, lairages and saleyards with which infected animals or contact animals have been associated must undergo a strict cleansing and disinfection.

Stacks of hay located near infected premises may quite well hold the virus, and these may be disinfected by superheated steam as was done by the Irish Department in 1912. Steam was injected from an engine into the ricks to a depth of 1½ feet to 2 feet. The heat penetrated to a depth of over 3 feet, and thermometer tests showed a temperature of 220° F. All dung, litter, and loose fodder must be burned. Such persons as have authority to enter infected places must wear rubber overalls and rubber high boots, as such can be readily disinfected. All persons before leaving infected premises may be conveniently rendered free from infection by fumigation with sulphur gas in cubicles erected on the premises.

Dogs and cats on infected premises should either be locked up or destroyed. The treatment of fields in which infected animals have been is a difficult problem; in Ireland they were freely sprinkled with freshly-burnt lime with the aid of sprinkling machines. Since the virus can remain active outside the body for a considerable but unknown period, it is not easy to say how soon such fields may be re-used for grazing purposes. The policy adopted by the Board of Agriculture during the 1911 outbreaks was to keep pastures free from susceptible animals for at least a month after disinfection. This was found to be a safe period on many occasions.

Packing material should be burnt after being used. Imported milk should be heated to 60° C. It was advised by the Departmental Committee of 1911 that hides and skins, hoofs, bones, &c., should be properly disinfected before being exported, and that a certificate to this effect should be required before the discharge of the cargo. It appeared that in the case of wet hides the inside of the skin should be washed with a solution of ½ per cent. formic acid or

with salt and water previous to being salted. In the case of dry hides, a method which appears to be effective even in the cases of the more highly resistant anthrax spores is the Seymour-Jones formic-mercury process. This consists in the immersion of the hides for 24 to 48 hours in a solution of formic acid and mercury bichloride and subsequent salting.

Löffler and Frosch found that in most cases in calves and adult cattle immunity is present 2 or 3 weeks after an attack and lasts for at least 5 months. It is said that this immunity is not developed in every case, and Strebel has observed the recurrence of the disease in cattle after 6 to 10 weeks. Löffler and Frosch worked out a method of immunisation which was employed with a certain measure of success in Germany, and which consisted in the simultaneous inoculation of lymph from the vesicles (usually 1/50 c.c.) and immune serum (10 cc. usually), immunity being established in about 3 weeks. Such a method it need hardly be stated could never be practised in this country owing to the almost certain creation of centres of infection. The use of an immune serum however, might be advocated to save the lives of cattle which have not been in close contact with infection but which could not be safely regarded without suspicion.

VARIOLA.

Variola (pox) is the name given to certain specific fevers associated with the presence of lesions which pass through well-defined stages, viz., papule, vesicle, pustule and crustaceous or scab stage.

Several animals have a definite variola, viz., man, ox, horse, sheep, goat and possibly pig and dog, and a good deal of controversy has occurred as to the exact relationship between them. The virus, which is obligatory, is in all cases capable of passing through a bacterial filter. The common idea is that cow-pox or vaccinia and horse-pox are identical, and a modified form of human variola or smallpox. It was noted that cow-pox and horse-pox often occurred under the same circumstances. Liquid from cow-pox vesicles produces a mild disease in man and a resulting immunity to smallpox (Jenner's method of vaccination). On the other hand sheep-pox is not transmissible to man or the ox, and cow-pox or smallpox lymph injected into sheep does not protect against sheep-pox. It is therefore held that sheep-pox is distinct from variola of man, horse and ox. The virus of sheep-pox does not spread naturally, and is difficult to convey experimentally to goats and *vice versa*. These two variolæ are therefore generally regarded as

distinct. While Chauveau and others have maintained that small-pox and cow-pox were distinct, Eternod and Haccius* state that human variola may be inoculated to bovines (calves), and after several generations of such passage becomes converted into vaccinia, the virus producing only a localised eruption on reinoculation to man. Gauducheau† has shown in experiments on monkeys that the virus of human variola immunises against that of vaccinia and concludes that they are types or varieties of the same virus. According to Pœnaru‡ the virus of smallpox cannot be transmitted to pigs. Further controversy has raged as to the connection between equine variola and the disease of horses known as contagious pustular stomatitis, but De Jong§ as the result of his researches concludes that these are one and the same and identical with cow-pox. De Jong was successful in his attempts to transmit the disease (contagious pustular stomatitis) from horse to horse and from horse to calf. With virus derived from the horse he was able to produce typical vaccinal pustules in children. He further found that ordinary vaccine was capable of producing stomatitis in horses, and that the virus of stomatitis passes through bacterial filters.

Sheep-pox (*ovine variola*) is a scheduled disease in this country to which it is at present exotic, though outbreaks have occurred. It exists in Eastern Europe, parts of Asia and Africa, and occasionally in France. The chief vehicle of contagion is the liquid from the vesicles in which the virus is abundantly present. The disease tends to be very virulent when introduced into a new district or country. Certain breeds of sheep possess a high degree of natural immunity, *e.g.*, Breton sheep were found by Nocard‖ in 1888 to be practically insusceptible. The virus is fairly resistant to certain destructive agencies, *e.g.*, sealed in tubes and kept in a cool, dark place, its virulence may be maintained for as long as two years. It is not destroyed by a certain degree of cold or desiccation, and it is stated that the disease may hang about infected premises for 5 or 6 months and that recovered animals may be infective for as many weeks. Infection is believed to occur by inhalation of virus contained in lymph or in the dust rising from dried scabs. Feeding with lymph fails to infect (Nocard¶). The period of

* *Journ. Comp. Path.*, 1891, Vol. IV., p. 73, Trans.

† *Trop. Vet. Bull.*, 1917, Vol. V., p. 132.

‡ *Journ. Comp. Path.*, 1907, Vol. XX., p. 158, Trans.

§ *Journ. Comp. Path.*, 1917, Vol. XXX., p. 242, Trans.

‖ *Journ. Comp. Path.*, 1889, Vol. II., p. 56, Trans.

¶ Hutyra and Marek, *Spec. Path.*, Vol. I., p. 305, Trans.

incubation is 4 to 5 up to 20 days. The course varies from mild types, in which mortality may be 8 or 10 per cent. and duration about 3 or 4 weeks, to much more malignant types with higher mortality.

A lasting immunity is conferred by a natural attack. A method of artificial vaccination (so-called "ovination") consisting of a subcutaneous injection of virulent lymph has been widely practised. The immunity conferred is said to last about 12 months, but a mortality of 1 or 2 per cent. of vaccinated animals is to be expected, so the method is only practicable when the disease is already prevalent. Borrel* introduced a method of sero-vaccination which gave excellent results when tried on large numbers of sheep. Nevermann, Miessner and Weichel† described details of a procedure as practised by them in Bulgaria. A sheep is inoculated with virus, and from the resulting vesicles 100 to 150 cc. of lymph are collected. This is diluted 2 to 6 times (depending on the virulence of the virus) with boric solution. Vaccination is carried out by the injection of a half to one drop subcutaneously in the ear. A mortality of ·6 to ·8 per cent. follows as against 5 to 50 per cent. in unvaccinated animals.

Cow-pox is a benign disease in which variolous lesions are usually situated on the udder or teats of adult females and on the lips or nostrils of calves. Any region of the body, however, may be attacked. The disease is largely spread by the hands of the milker.

Horse-pox is benign in course, lesions being seen on the heels or pasterns or on the muzzle and lips. As stated above, this is considered by De Jong to be the same affection as the so-called "contagious pustular stomatitis or dermatitis" since lesions occur both on the mucous membrane of the lips and on the skin in various parts of the body. The incubation period is said to be 4 to 6 days, and the virulence of the disease appears to diminish as it progresses. Horse-pox is largely transmitted by means of saliva.

Swine-pox is said to occur in pigs not more than 10 weeks' old, spreading among these by contagion. The mortality is variable, depending partly on the virulence of the virus. The disease has been said to occur in Hungary, and more recently Pœnaru ‡ has described the existence of the disease in Roumania, mentioning an outbreak which started in 2 pigs about 6 weeks' old and spread

* Hutyra and Marek, *Spec. Path.*, Vol. I., p. 317, Trans.

† *Trop. Vet. Bull.*, 1917, Vol. V., p. 260.

‡ *Journ. Comp. Path.*, 1907, Vol. XX., p. 158, Trans.

to 30 others, of which 15 died. The disease lasted 15 to 30 days. Monod and Velu* described outbreaks in Morocco affecting young pigs rarely over 3 or 4 weeks' old. The virulence was variable, the mortality being 5 to 80 per cent.

RABIES.

Rabies (hydrophobia, lyssa) is propagated in nature by canine animals, though all warm-blooded animals, including man, are susceptible. The cause is considered by most observers to be an ultravisible virus, though others maintain that the so-called Negri bodies, which are as a rule discoverable in various parts of the nervous system, are protozoan in nature and are the actual cause. The virus which is contained in the nervous system and also in the saliva of animals affected is obligatory, the disease never arising sporadically. Nocard and Roux discovered the saliva of dogs to be infective at least 2 to 4 days before symptoms appear, while Konradi states that the bites of rabid dogs are dangerous 8 days before the onset of symptoms.† Rabid animals of nearly all species develop a marked tendency to bite, and transmission in natural cases occurs in this way. Even animals which are naturally docile, *e.g.*, sheep, become very aggressive when attacked by the disease. An interesting outbreak occurred in 1887 among the deer in Richmond Park, and this same tendency was noted. The disease existed in this country certainly as far back as the tenth century, and was at one time of fairly frequent occurrence, as may be seen from the following table :—

Year.	No. of Cases.	Year.	No. of Cases.
1889	312	1897	151
1890	129	1898	17
1891	79	1899	9
1892	38	1900	6
1895	672	1901	1
1896	438	1902	13

During the period 1848 to 1902, 1114 persons are stated to have died of hydrophobia in Great Britain.‡ With the exception of one dog, which died while in quarantine in 1915, Great Britain was free from the disease from 1903 to 1918, in which year the disease was again introduced.

* *Trop. Vet. Bull.*, 1916, Vol. IV., p. 115.

† Hutyra and Marek, *Spec. Path.*, Vol. I., p. 468, Trans.

‡ *Annual Report*, C.V.O., Bd. of Agric., 1903.

The reintroduction of rabies into Great Britain during 1918 was due to abnormal war conditions. "The executive preventive authorities at the ports had to meet a very abnormal situation, in which their ordinary powers and facilities were greatly curtailed; this was accentuated by aerial traffic. The dog-importing public was also enormously increased and altered in character." The first suspicious case was brought to the notice of the Ministry (then the Board) of Agriculture on 30th August, but as the material sent for examination was not fresh the result was inconclusive though highly suspicious. As the result of inquiry rabies was declared to exist on 7th September, and an Order was issued prohibiting the movement of dogs out of Cornwall and Devon and applying muzzling regulations to an area around Plymouth. Later the muzzling regulations were extended. From 24th August to 31st December, 1918, 112 cases of rabies were confirmed. It is certain that the disease had been in existence for some time undiscovered, and this greatly increased the difficulty of tracing infected animals. "Two important fortuitous circumstances, however, aided the operations. Firstly, the majority of the cases were of the paralytic form, which greatly curtailed their wanderings and their ability to bite; and, secondly, the majority of cases which ran elected to take a westerly direction, and by so doing came up against an effective sea barrier. Had it not been for these factors the situation might have been very much worse."*

The period of incubation is variable, and rarely less than 15 days in natural cases and generally 1 to 3 months. In 3 horses bitten by a rabid dog Beurnier and Bocquet† noted the incubation period to be respectively 21, 88, and 105 days. At times the period may extend to a year or more. The course once symptoms are shown is very short, generally about 4 to 7 days. The mortality in dogs is very high, though experimental cases occasionally recover; thus Högyes‡ states that of 159 dogs experimentally infected 13 recovered, though admittedly 7 of these had received anti-rabies treatment. According to Remlinger,§ cases of recovery are occasionally noted in nature, thus a good many examples have occurred of persons having died of rabies who had been bitten by dogs which had remained alive. This observer also noted that the virus persisted in the saliva of a dog experimentally infected

* *Annual Report* of C.V.O. of Bd. of Agric., 1918, Abs. from *Journ. Comp. Path.*, Vol. XXXII., Dec., 1919.

† *Journ. Comp. Path.*, 1889, Vol. II., p. 70, Trans.

‡ *Journ. Comp. Path.*, 1889, Vol. II., p. 359, Trans.

§ *Journ. Comp. Path.*, 1907, Vol. XX., p. 266, Trans.

for at least 5 days after complete recovery. It is certain that by no means every person bitten by a dog proved to have been rabid subsequently develops symptoms. The same is true in the case of animals in which probably not more than a half of those bitten by rabid animals develop the disease (Hutyra and Marek).

The virus in nervous tissue retains its virulence for months if protected from desiccation and putrefaction (Pasteur). Fluid saliva has been found to be infective even after 24 hours (Gibier). The virus is destroyed at 52° to 58° C in 30 minutes (Högyes). The virus is resistant to cold and to putrefaction, *e.g.,* Galtier found the medulla of a dog that had been buried for 44 days to be still virulent. The virus is also resistant to glycerine.*

Starting with the observation that dogs can be artificially immunised, Pasteur developed his well-known method of conferring immunity upon persons who had been bitten by animals affected with rabies. As above stated, the period of incubation in rabies is, in general, a long one, and Pasteur's object was to immunise the person during this period and so avert attack by the natural virus. He found that on injecting rabbits subdurally with natural or so-called "street" virus the period of incubation was about 15 days, but that this could be reduced by passage from rabbit to rabbit to about 6 or 7 days. This virus, which he called the fixed virus of rabies, is exalted in virulence only for the rabbit and only by subdural inoculation; for other animals, including man, the fixed virus is attenuated. The fixed virus is present in the spinal cord of the rabbit and this, after death, is cut out and suspended in a bottle containing solid potash, which has the effect of absorbing moisture from the air, and so leads to gradual desiccation of the cord, which, in turn, leads to gradual loss of virulence, so that by the fourteenth day the cord is no longer infective. People who have been bitten by rabid animals are submitted at Pasteur Institutes, as soon as possible after being bitten, to a course of treatment consisting of subcutaneous inoculations at intervals of a few days with rabbits' spinal cords of gradually increasing virulence. The length of the course varies according to the position and extent of the bites. If these are very numerous or situated about the head, the person receives injections over a period of 3 weeks; if the bites are not serious and are situated on the arms or legs the course lasts about a fortnight. Large numbers of people have received this treatment since its inception in 1885, and the mortality among the second class (bites on arms or legs) was less than 1 per cent. Among those bitten badly or about the head

* Hutyra and Marek, *Spec. Path.,* Vol. I., p. 466.

the mortality is about 4 per cent., while the mortality among such untreated is about 80 per cent. According to Lenz, protection is complete only on the fourteenth day after treatment ends.

Since 1885 several modifications of the original Pasteurian method have been introduced. Fermi* states that immediate immunity and better results are obtained by his mixed method. His vaccine consists of a 5 per cent. emulsion of potent fixed virus plus 1 per cent. phenol, using brain (more active than cord) of rabbit or dog. To 2 parts of this he adds 1 part of hyperimmune serum prepared by injection of this vaccine into horses. Treatment with this serovaccine is given for 5 to 10 days, followed by vaccine alone up to the twenty-fifth day.

It has also been shown to be possible in the case of the domesticated animals to take advantage of the lengthy period of incubation for the purpose of conferring immunity; thus Galtier produced immunity in sheep and goats by injecting saliva or emulsion of medulla from rabid dogs intravenously. Attempts have been made to produce an anti-rabies serum by gradually immunising horses against the disease. Pfeiler states that he has obtained good results by intraspinal injections of such sera, though up to the present the method has not been practised to any great extent.

The freedom of these islands from the disease from 1903 to 1918 is ascribable to the regulations of the Board of Agriculture, the chief of which is that dogs admitted to this country must be kept in quarantine on properly appointed premises for a period of six months. Had it not been for the war there is little doubt but that the outbreaks during 1918 and 1919 would not have occurred.

As soon as cases of rabies are reported and confirmed, infected areas are declared within which all dogs must be effectively muzzled. The extent of the area will depend upon circumstances, but it would in any case be wide owing to the marked tendency of rabid dogs to stray. It is very important that all stray and ownerless dogs should be captured and destroyed, as experience in the past has shown that the disease is largely spread through the agency of such. The regulations would remain in force for a year or so after the last case.

CANINE DISTEMPER

Canine distemper is a highly contagious epizootic disease of the candidæ, of which the most characteristic symptoms are fever

* *Trop. Vet. Bull.*, 1917, Vol. V., p. 195.

and catarrh of mucous membranes of the conjunctiva and of the upper part of the respiratory tract, and eruptive lesions of the skin. Complications such as pneumonia, nervous symptoms, &c., often appear during the course of or subsequent to the attack. Many diverse organisms have been considered by different workers to be the cause of distemper, but at the present time it appears to be probable that these are secondary invaders. From the researches of Carré in 1905* it seems that distemper is due to an ultravisible virus. This view was confirmed by Lignières and is accepted by Hutyra and Marek. Carré found the virus to be present in the blood, and especially in the serous nasal discharge in the early stages of the attack. Such discharge, even after being passed through a bacterial filter, reproduces the disease on subcutaneous injection. The virus disappears from the nasal discharge, or at least cannot be demonstrated therein at later stages of the attack. More recently (1913) Torrey and Rahe† have described an organism known as the "*Bacillus bronchisepticus*" but it seems to be doubtful whether it is the real cause.

Dogs of any age are liable to attack, though young dogs are more susceptible and the disease appears in them more frequently. Its distribution is universal, and it is said to be especially prevalent in wet chilly weather. The course of the disease is very variable. Mild cases may recover in a week, though the average duration is 3 to 4 weeks. The period of incubation was found by Carré to be 3 to 4 days after artificial infection, but in natural cases it is probably rather longer. The mortality varies within wide limits, *e.g.*, Gray ‡ considers that with Japanese spaniels it may reach as high as 90 per cent. and gives the average for all dogs at about 25 per cent.

The contagium is chiefly contained in nasal and ocular discharges and, to a less extent, in the fæces and urine. Direct contact between diseased and healthy dogs is probably the chief means of spreading the disease, though the virulence of the contagium and the resistance of individual dogs is very variable. According to Hutyra and Marek, the virus most probably enters the body *per os* along with food or water. Failure to diagnose the real nature of the malady in its early stages is not infrequently followed by the appearance of the disease in a healthy kennel, as, for instance, in a veterinary infirmary. Kennel men undoubtedly spread the disease in their own kennel by carrying the contagium on their

* *Revue Vet.*, Vol. V., p. 321.

† *Journ. Med. Research*, Vol. XXVII., p. 291.

‡ Wallis-Hoare, *System. Vet. Med.*, Vol. I., p. 659, 1913.

clothes and hands. Veterinary practitioners are less liable to do so as they would wash their hands after manual examination of suspected subjects. Dog shows act as distributing centres, and the risk involved in the handling of each dog by the veterinary surgeon as it enters the showroom is a real one. The excitement and fatigue of a show predispose susceptible animals to infection. Dogs returning from stud, hound puppies from their "walkers," and boarders from dogs' homes often carry the disease with them. Infective dogs running loose on the streets are probably the most common distributors. H. Gray* considers that mediate methods play only a very small part in the distribution of the disease.

Preventive Measures. — All dogs suspected of having or known to have recently recovered from distemper should be carefully isolated and not allowed to cohabit with other dogs for a month after they have apparently recovered. Dogs sent to shows or to kennels for stud purposes should be accepted only with a written guarantee that the premises from which they come are free from disease and have been so for at least one month. Dogs returning from stud or show should be kept in quarantine at the owner's kennels for one month. Veterinary surgeons examining dogs at shows should exercise the greatest care in handling animals, and should immediately wash their hands in disinfectant after examining a suspicious case. Hound puppies returning from the "walker" should be isolated for a month and the kennels should be clear of disease before the puppies are admitted. Veterinary infirmaries should have a ward set apart for distemper cases, and the patients therein should be attended to last. Special overalls should be worn while attending the distemper ward, and the hands carefully cleansed afterwards. Thermometers should be washed as a matter of routine. Kennels, if properly constructed, are easily freed from infection by the application of hot water, soap, and any suitable disinfectant. Feeding utensils and other appliances must be cleansed and disinfected. Dogs' coats for hospital purposes should be made of flannelette of simple and inexpensive design and destroyed after recovery or demise of the patient. The wood work of kennels may with advantage be painted with creosote paint after the preliminary scrubbing.

Several methods of vaccination against distemper have been introduced. Jenner noted the resemblance between distemper and smallpox and considered it to be canine variola, and advised vaccination with cow-pox virus, but the method was found to be useless. Phisalix introduced a method of vaccination which was

* Wallis-Hoare, *System. Vet. Med.*, Vol. I., p. 654, 1913.

said to have been attended with very good results. The method was examined by a Committee appointed in 1904, but was found to be useless.

FELINE DISTEMPER.

Feline distemper is if anything more highly contagious than the canine form, from which it is considered to be a distinct disease. The causative agent is not known. The period of incubation is about the same as that of the canine disease, and it is also as widely distributed. Spring and autumn are the chief seasons for its appearance, and cats of any age are liable to attack. The rate of mortality is frequently very high; in catteries and veterinary infirmaries 50 per cent. of the cases may be expected to end fatally. Infection spreads extremely rapidly in such places, and the contagium is probably air-borne. What has been said under canine distemper concerning transmission and prevention also applies here. Cat shows often act as distributing centres, and the disease may also be introduced by a cat returning from stud. Cages in which cats are kept are dangerous sources of infection. The contagium, however, seems to be more resistant than that of canine distemper and fumigation with sulphur is desirable. The premises or parts contaminated should afterwards be freely exposed to the air and left vacant for a fortnight or longer. Gray considers that cats are capable of carrying the virus for an indefinite period, even for years, and infect each litter as it appears. Though some cats apparently possess a natural immunity, to those susceptible one attack offers no protection from a second, and Gray is of the opinion that on the contrary one attack may predispose to others.

STUTTGART DOG DISEASE.

Stuttgart disease (contagious gastro-enteritis, canine typhus) is a disease of dogs, the characteristic features of which are gastritis and ulcerative gangrene of the oral mucous membrane. The cause is unknown. Some clinicians look upon it as being a form of distemper, but this view is most probably wrong. It seems to have first attracted notice in various towns in England, and especially on the south coast, in 1898, and no doubt is similar to the disease which prevailed in some parts of Germany in the latter part of 1898. The German disease was well described by Klett* of Stuttgart in 1899. Klett looked upon the disease as being

* *Journ. Comp. Path.*, Vol. XII., p. 36, Trans.

contagious, direct infection occurring from animal to animal or by mediate methods, *e.g.*, by food, water, &c., but even this appears to be doubtful. It seems that the disease is not transmissible from one animal to another either by contact or by experimental inoculation. Many observers have noted that of several dogs in a household only one may be affected. Baird, who had considerable experience with the disease in Edinburgh in 1896 to 1898, repeatedly noticed this peculiarity, and also that it occurred in localities, so that when one outbreak became as it were exhausted, the disease appeared elsewhere in the city, outside of which it was rarely met with.

The disease is to be met with in practically all parts of the United Kingdom, but it was especially prevalent about 1898. The type of disease appears to vary to some extent, the average course being 8 to 10 days, but in very severe cases it may be only 4 to 6 days. The mortality rate is extremely high. Of 42 cases treated by Klett 32 died. Dogs of all ages and of any breed are susceptible.

Preventive Measures cannot be suggested with any degree of confidence owing to our insufficient knowledge concerning the etiology of the disease and its methods of transmission. Though a connection between the house garbage bucket, which is undoubtedly the cause of many cases of gastritis or "ptomaine" poisoning, and this specific disease has never been demonstrated, every effort should be made to confine dogs to the house until the refuse container has been emptied and removed.

SWINE FEVER.

Swine fever (hog cholera, pig typhoid) is a highly contagious disease of the pig caused by an ultravisible virus (Deschweinitz and Dorset, 1913) and is of a typhoid-like nature, lesions due to secondary organisms, so-called "swine fever bacilli," being present with great constancy in the alimentary tract. The latter are normal intestinal inhabitants which exert pathogenic activity when the body is invaded by the ultravisible virus. The pig is the only animal susceptible.

Swine fever is epizootic in America, the United Kingdom, and in Europe generally. It is enzootic in some districts, while others keep remarkably free from it. Available evidence points to its having been introduced from the Continent at a date prior to 1858 and the disease in a short time assumed formidable proportions. Since that time swine fever has been constantly present in the British Isles and the problem of complete eradication has not yet been solved. An idea of its ravages may be gained from the follow-

ing statements :—between 1894 and 1916 the number of outbreaks varied between 1196 (in 1904) and 6305 (in 1895), leaving out 1905, in which only 817 outbreaks were recorded. The number of outbreaks in 1914 was 4356 and in 1916, 4331. During the whole period 1894-1916 the disease existed in from 58 to 77 counties. In Great Britain its distribution is unequal and it by no means follows that a county with a large pig population has a correspondingly high rate of disease. The north and west of Scotland, parts of Wales, and to a certain extent the Border district are practically free from it. In Ireland, as seen from the following table, it is most prevalent in Leinster (the Borough of Dublin accounting for a large proportion of the outbreaks), and is rare in Connaught :—

	1914	1915	1916
Ulster	3	37	19
Munster	29	34	47
Leinster	146	170	246
Connaught	15	12	...
	193	253	312
Borough of Dublin	90	107	125

In the following table are shown the pig population and the number of outbreaks of swine fever for each of the four divisions of the United Kingdom taken from the official returns. (For the purpose of more clearly showing the disease incidence, the outbreaks per 100,000 pigs have been calculated for the average of the three years given.)

Division.	Pig Population and Outbreaks.				Outbreaks per 100,000 Pigs.
	1912.	1913.	1914.	Average.	
England, Pigs . .	2,270,154	1,911,520	2,259,951	2,147,208	145.4
Outbreaks	2,794	2,384	4,189	3,122	
Scotland, Pigs . .	159,127	131,753	152,768	147,882	37.8
Outbreaks	58	52	58	56	
Wales, Pigs . .	226,516	190,582	221,530	212,876	47.4
Outbreaks	68	137	109	101	
Ireland, Pigs . .	1,323,957	1,060,360	1,305,638	1,229,985	14.5
Outbreaks	215	129	193	179	

Swine fever is as a rule more prevalent in districts thickly

populated with pigs and in such districts it may be considered to be enzootic. There does not appear to be any particular seasonal incidence in the United Kingdom, possibly on account of the more equable temperature. In the middle-west of the United States of America however, the disease shows a marked seasonal incidence, reaching its greatest height in October and November and then dying down rapidly, particularly after snow falls, and reaching its lowest point in February. In the southern States, as in the United Kingdom, possibly owing to the more equable temperature, severe outbreaks occur at any season of the year.*

With regard to age incidence, in most outbreaks the young stores are the first to become affected, but this is not invariably so and pigs of any age are liable to attack.

The period of incubation is at least 4 days, often 10 to 20 days. Hutyra and Köves† found that in 5 lots of pigs the first symptoms were observed during the second half of the first week, in 18 lots in the course of the second week, and in 3 lots in the course of the third week, and this variability was considered to be due to individual susceptibility and to the degree of virulence of the virus. It is doubtful if the virus remains active outside the body for a longer period than 14 days, though the author has known 30 clear days elapse between the slaughtering out of the entire animals in one piggery and the first visible signs of disease in the adjoining piggery which was separated by a brick wall (infection was possibly carried by wagtails).

The mortality varies greatly with the character of the outbreak, depending principally upon the very varying virulence of the virus. In very acute outbreaks from 70 to 90 per cent. of deaths may be expected, the disease being most fatal in young pigs. It is seldom fatal in less than a week and it often lasts 2 or 3 weeks. The average mortality for all outbreaks is placed at about 30 per cent.

The virus is present in the blood and also in the fæces and the urine, and it is through the agency of these excretions that the disease is spread throughout the piggery and from one place to another. Infection occurs by ingestion, and, the disease being strictly contagious, the source of infection is always the diseased pig. Once the disease is introduced into a piggery, it is readily disseminated by attendants carrying infection on their boots, brushes, and the like. The disease may in the same way be spread by castrators, dealers and butchers, rats and birds. Infected particles of manure, &c., may be transported by the wind. Pigs are

* *Farmers' Bulletin*, 834, U.S. Depart. of Agric., August, 1917.

† *Journ. Comp. Path.*, 1917, Vol. XXX., p. 176, Abs.

sometimes carried to market when infected by swine fever, and when straw is used in the cart, it may be thrown out and used by others carrying pigs to healthy premises. Railway trucks or vehicles used for carrying swine may be the means of infecting healthy animals. It is important to note that in an outbreak many adult pigs survive after having passed through a chronic attack, and such pigs, which usually remain unthrifty, are often infectious. Other animals may merely show a rise of temperature without any clinical symptoms, but with a resulting powerful immunity.

The Departmental Committee, inquiring into swine fever,* concluded that: "The manure of pigs suffering from swine fever is infective. That a period of 14 days may be regarded as sufficient to bring about the disinfection of infective manure through natural causes. That rats are not, as has been suggested, pathological carriers of swine fever. That all available evidence suggests that swine fever is not disseminated by external parasites. That while persons, vehicles and animals which have been in contact with infected pigs or premises may carry infective material mechanically within the area of their movements, subject to the time limit indicated above, the evidence leads the Committee to the conclusion, that all wide dissemination of disease is due to the movement of infected pigs. That a pig may become infective in three days after it has itself contracted infection and before it has actually exhibited clinical symptoms of disease, and a pig which has contracted the disease may continue to be infective for a variable period the extent of which has not yet been fully ascertained, but which is often of considerable duration. That there would appear to be cases in which healthy pigs that have not been visibly affected by swine fever, and which on post-mortem examination show no evidence of having suffered from swine fever, are infective and continue to be so for a considerable time."

Miessner† states that: "The virus exhibits considerable resistance to destructive agencies; thus, serum containing virus can stand being heated to from 45° to 46° C for 24 hours. The virus is also resistant to drying and sunlight, but is destroyed by putrefaction in 8 days."

PREVENTIVE MEASURES.—If swine fever is to be kept under control and eventually eradicated, it is imperative that the provisions of the swine fever Order be carried out. Magistrates who fail to inflict a substantial penalty on offenders are a serious hindrance to attempts to reduce the number of outbreaks. The

* *Final Report*, Part IV., Cd, 8045.

† *Epizootics and their Control in War*, 1917, Trans. by Liebold.

report of the Departmental Committee, which was issued in 1915, stated in its general conclusions that "the continued prevalence of swine fever appears to be due principally to its highly contagious character, and the difficulty of its recognition by the pig owner in its early stages and in its milder forms. To these causes must be added the difficulty of completely tracing the place of origin and the movement of pigs by which the disease has been spread. The extirpation of the disease is practicable only by such drastic measures of slaughter as would involve a prohibitive outlay, and by such severe restrictions on movement as would be fatal to the industry of pig keeping. Present circumstances, therefore, do not encourage the view that the extirpation of swine fever can be speedily accomplished." They recommended further that "the attempt to extirpate the disease by general slaughter should be abandoned for the present, and that the immediate object of future policy should be (*a*) to reduce mortality from the disease; (*b*) to control the spread of the disease."

Certain measures should be observed with a view to reducing the prevalence of the disease. Curtailment, as far as possible, of the store trade; pig feeders should breed and feed their own stock. Breeders should, if possible, keep their own boars and deny their use to other parties. If fresh stock is brought in or sows return from the boar, they should be kept in strict isolation for at least a month. Carts, crates, nets and the like should not be lent to neighbours. Visiting between one piggery and another should not be encouraged. Rats should be exterminated, as they may act as mechanical carriers of infection. Castrators should not be employed; owners or their attendants should castrate their own pigs. The premises should be hygienically constructed and excreta and yard washings must not be allowed to flow across the highway or in close proximity to neighbouring premises.

Immunity.—An attack of the disease leaves in the recovered animal a very considerable degree of immunity, and an attempt has been made in recent years to put this fact to practical use on a large scale for the purpose of building up immune herds. Pigs can be hyperimmunised by a series of injections of defibrinated blood taken from pigs at the height of an attack, and such pigs yield a serum which is very potent as a protective agent before infection, and according to Hutyra and Köves* within six days after. It was recommended by the Departmental Committee which reported in 1915 "that in order to reduce mortality, the use of protective serum without avoidable delay in infected herds should be encouraged

* *Journ. Comp. Path.*, 1917, Vol. XXX., p. 177, Abs.

by every possible means, and in particular by facilitating the supply of serum; that the production of immune herds by simultaneous administration of serum and virus should be undertaken where pig owners so desire, on premises selected as suitable and under careful supervision and restrictions; that in order to control the spread of the disease, the isolation of infected premises should be maintained by restrictive regulations, but that such restrictions should allow the introduction to infected premises of pigs to be treated immediately with serum."

Stockman's conclusions in the final report (August, 1915) of the Departmental Committee were as follows:—

1. That treatment with serum alone is of great value on infected premises in saving the lives of those pigs which have escaped infection at the time of treatment. It follows from this that the sooner the treatment is applied on such premises and the greater the efforts made before its application to isolate the healthy pigs from those which are ailing or doubtful, the better the results are likely to be.

2. That immediately after treatment with serum it is advisable to attempt to convert the passive immunity into active or lasting immunity by allowing the healthy pigs which have been treated to come into contact with those which are ailing. If the pigs do not acquire active immunity, serious infection may re-assert itself after the temporary protection derived from the serum alone has passed off. The outbreak may thus be prolonged and the losses will probably be increased.

3. That, although it is possible that serum treatment exerts some moderating influence on the course of the disease if applied while a pig is in the earliest stages of infection, it has no curative action when infection has gained a distinct start.

4. That an affected piggery can be successfully restocked with pigs provided the new animals are injected with serum on arrival, and immediately afterwards brought into contact with the existing infection.

5. That in many cases the results obtained in the treatment of young suckers were disappointing. (*Vide infra.*)

It is advised that the dose of serum should not be less than 20 cc. Unfortunately it seems that owing to the variation in the susceptibility of swine and of the virulence of the virus, the results of vaccination in the field are irregular, some pigs showing very severe reactions and centres of the disease being liable to become established. This is particularly unfortunate, as the immunity acquired by vaccination has been found to be both high and durable. The method which appears to be attended with the least risk is

exposure of healthy pigs, which have received serum, to contact with affected pigs. Next in order of safety is feeding such serumised pigs with virus, but unfortunately this requires rather a large amount of virulent blood. Inoculation of the virus subcutaneously is still more risky.

Some vaccinated pigs, although not showing serious symptoms, may nevertheless be found on subsequent slaughter to have had considerable intestinal lesions. Only sound pigs should be vaccinated, and during the process they should be protected from outside influences which are likely to have the effect of lowering their vitality. In conclusion, it appears to be desirable to endeavour to find some method of producing active immunity which is not attended with the dangers and disadvantages met with under the present procedure. At any rate, it seems that the simultaneous use of serum and virus should be restricted to centres where outbreaks are frequently occurring and where losses from the disease are very high. The results of the use of serum over a period of 12 months (Sept. 1915 to Sept. 1916) are discussed by the Chief Veterinary Officer, Board of Agriculture, in his annual report for 1916, from which we have quoted verbatim. Serum treatment was applied in 2100 outbreaks :—" Of the 77,900 pigs included in the outbreaks treated with serum the total death-rate from swine fever, which included a large number of deaths in pigs which for various reasons were not treated, amounted to 34·6 per cent. The number slaughtered for food during the outbreaks amounted to 25·8 per cent. The number freed at the end of the outbreaks amounted to 38·6 per cent., which included a large proportion of the breeding stock, most of the stores having been slaughtered in accordance with the object for which they were intended. Deaths from other causes than swine fever are omitted.

" During the same period 38,229 pigs were involved in outbreaks on premises upon which serum treatment was not adopted. The total death-rate amounted approximately to 52 per cent. The number slaughtered for food during the outbreaks, often at an early stage, to save their commercial lives amounted approximately to 33·2 per cent. The number freed at the end of the outbreaks amounted to only 14·8 per cent. In both cases the death-rate is calculated in relation to the total number involved.

" The claim for serum treatment is that it saves pig life on infected premises, and it would appear from the above figures that, viewed from the death-rate alone and under the conditions obtaining in practice, without taking into account special benefits, such as conservation of breeding stock and business, there was a benefit

of 17·4 per cent. in favour of the pigs on premises where serum treatment was applied, notwithstanding the fact that the deaths on these premises included a very considerable number of pigs, which for various reasons were not treated."

"Certain limitations were put upon the results obtainable from serum treatment by the conditions under which it has to be applied in practice. The limitations arise mainly from the Authorities being dependent upon owners for immediate notice of suspected outbreaks, and from the fact that it is seldom either practicable or useful to apply serum treatment before disease has appeared on the premises; on an average, about 30 per cent. of the pigs were dead or in the grip of infection before opportunity arose for treatment. Notwithstanding these limitations, it appears that serum treatment achieved very considerably better results at infinitely less cost than other methods previously tried for dealing with swine fever. It would also appear that the effect of these limitations could be lessened by earlier reporting."

The chief advantage of the use of serum is that it enables one to save some pigs alive, and in particular valuable breeding animals. Thus at the end of the outbreaks (2100) mentioned in the report for 1916, among those untreated with serum only 34·2 per cent. of the breeding stock were left alive, while among those treated 66·8 per cent. were freed. It is difficult to apply the serum to suckers owing to the fact that these are born at odd times and because for the first few weeks they do not get the chance of acquiring an active immunity after receiving serum, and it is often not possible in practice to give them more than one dose. The mortality among suckers even after treatment, therefore, tends to be high.

CONTAGIOUS SWINE PNEUMONIA.

In Germany there were first described outbreaks of a disease to which the name "Schweinseuche" was given and which is known in America by the name of "swine plague," and in which pneumonia is said to be a constant lesion. In this country cases of pneumonia occur in pigs sporadically and also quite commonly as complications of swine fever, though only in rare cases are they actually caused by the swine fever organism.

It is possible that the cases of Schweinseuche are in reality sporadic in origin and due to the same cause exerting its action on a number of pigs at the same time. The causal agent is a pasteurella which is capable of existing as a saprophyte in the

ground. A similar organism has been isolated from the mouth and air passages of healthy pigs, and it appears that it may reside there as a harmless inhabitant until the vitality is lowered by the swine fever virus.

SWINE ERYSIPELAS.

Swine erysipelas is a specific disease of pigs associated in the acute form with a peculiar discoloration of the skin and due to a bacillus, the *bacillus of swine erysipelas* (Löffler, 1882). The disease was for a long time in this country confounded with swine fever, but M'Fadyean* in 1891 first drew the distinction and described three cases which had occurred in remote parts of England. For some time previous to this the disease had been recognised on the Continent as a morbid entity.

The other domesticated animals are not susceptible to natural infection, but instances have occurred in which man has become inoculated through skin abrasions. Infection is most probably telluric in origin and the organism leads a saprophytic existence in the soil. Its saprophytic life explains quite well the marked seasonal incidence of the disease, the majority of acute cases occurring in the summer when presumably multiplication of the organism in the soil is most rapid. Cases are, however, occasionally met with in the autumn and spring, but in these cardiac valvular lesions are generally present following an acute attack. Some observers consider that the bacillus of swine erysipelas is frequently present in healthy pigs, and the organism has been isolated from the tonsils and ileo-cæcal valves of such. These bacilli in healthy pigs have been considered to have originated outbreaks, and the facts just noted may explain the occasional occurrence of the disease among pigs kept under exceptionally good hygienic conditions.

On the Continent swine erysipelas appears as a rule as an acute and very infectious malady, producing large outbreaks with usually a high mortality. In this country, however, such outbreaks have only rarely been met with, not more than a few cases as a rule appearing in any one set of premises and the disease showing no marked tendency to spread. Thus in 1914 the average number of pigs in each herd attacked was only 12, and of these only 14·3 per cent. became affected. In 2057 of the 2892 outbreaks which occurred in 1914 only one pig was attacked. Furthermore, experiments made by a Departmental Committee appointed in 1895 showed that it is difficult to transmit the disease by feeding pigs

* *Journ. Comp. Path.*, 1891, Vol. IV., p. 316.

on such material as the vegetations on the cardiac valves, artificial culture, &c. It is nevertheless the cause of considerable loss to pig owners, and as the Chief Veterinary Officer, Board of Agriculture, in his report for 1914 points out, "the loss from swine erysipelas is, in a sense, often much greater than from swine fever, for the mortality in the latter disease is usually among the young pigs, while the highest mortality in the former disease is usually among the fatting or fat pigs, upon which a considerable amount of food-stuffs has been expended."

The disease is widespread in Great Britain, "extending from the Orkneys, north, to Cornwall, south, Cardigan, west, and Norfolk in the east."* Swine erysipelas is only brought to the notice of the Board of Agriculture through its being reported for swine fever, so that the returns are not complete. From available reports the Chief Veterinary Officer, Board of Agriculture, compiled a table showing its distribution and the ratio of outbreaks to pig population, and from the 1914 report the following have been selected :—

County.	Pig Population.	Outbreaks in 1914.	Ratio.
Devon	105,220	1	1 in 105,220
Lincoln	120,154	204	1 in 589
Cambridge	65,214	193	1 in 337
Somerset	115,368	9	1 in 12,818
Dumfries	10,468	Nil	Nil
Fife	6,519	2	1 in 3,260
Forfar	7,465	64	1 in 117
Wigtown	16,718	1	1 in 16,718

Outbreaks, of which there were 2892 in 1914, were reported in 67 counties. It is especially prevalent in the eastern counties, and the Chief Veterinary Officer, Board of Agriculture, suggests as a reason for this that the soil there is suitable for the bacillus, and that it can remain virulent a long time outside the bodies of animals.

The usual ages at which pigs are attacked are from 3 to 12 months, though older pigs are sometimes affected. Concerning the age incidence, valuable statistics are to hand in the reports of the Chief Veterinary Officer. The table given for 1914, which is very similar to those of 1913 and 1915, is here given *in toto*.

* *Annual Report*, C.V.O., Bd. of Agric., 1913.

Class of Pig.	Total Number in Infected Herds.	Number Affected.	Percentage Affected of Total.
Boars	225	27	12.0
Sows	3,051	423	13.9
Unweaned pigs	5,500	289	5.25
Fatting pigs	13,514	2,592	19.2
Store pigs	12,564	1,861	14.8

The Chief Veterinary Officer draws attention to the fact that stores are also attacked and that unweaned pigs do not always escape. The author has seen a very acute outbreak in unweaned pigs less than a fortnight old.

Infection usually occurs by ingestion, probably through the medium of excreta. On the Continent the disease has been noted to occur following castration. With pigs housed in cement concrete sties with cement floors and which never leave the sty until they go to slaughter and where all the food is cooked, it is possible that the contagium is brought in on straw used for bedding.

Preventive Measures.—These consist of isolation of affected pigs, and deep burial of the dead. Once an outbreak has occurred it is a good plan to keep the affected and suspects in sties and so lessen risk of grossly contaminating pastures. Sties and feeding appliances must be disinfected. Infected litter must be kept apart from other litter and treated with quicklime or burnt. No fresh pigs should, of course, be introduced until the outbreak is at an end. Since swine erysipelas is due to a saprophytic organism normally present in the soil it will never be completely stamped out, and owing to this the Chief Veterinary Officer, Board of Agriculture, does not advocate its compulsory notification, stating that if it were adopted it " would probably result in a maximum amount of inconvenience to pig owners with a minimum amount of success."

One attack produces immunity. Although in this country one does not often see extensive outbreaks such as occur from time to time on the Continent, these do occur.

On the Continent methods of producing immunity have been practised to a large extent. In France at one time (1882) Pasteur's method was used, which consisted in injecting with a certain interval two living vaccines attenuated in virulence for the pig by means of passage through rabbits. Pasteur's method was found to be not entirely free from danger. More satisfactory is the method of Lorenz (1893), which consists in injecting a dose of protective serum obtained from hyperimmunised horses, followed a few days

later by a dose of slightly attenuated bacilli. The method has been employed with good results in the case of a large number of animals in Germany. The duration of immunity is from six months to a year. Leclainche has introduced a modification of Lorenz' method by giving at first a mixed injection of serum and vaccine, followed at an interval of about 12 days by vaccine alone. It is advisable to carry out methods of vaccination during the spring of the year, as the animals may then be expected to exhibit immunity during the swine erysipelas season. When the disease already exists, pigs showing high temperatures should receive serum only.*

REDWATER.

Bovine redwater (bovine piroplasmosis, tick fever, moor ill, bovine malaria, texas fever) is known in many parts of the world. Texas fever is similar or identical with the British disease, but cases are as a rule more severe. In Great Britain it occurs as an enzootic in Ireland, in parts of Scotland, and in certain districts in the south-west of England. It is an inoculable disease, due to the presence in the blood of the protozoan organisms, piroplasms, which were first correctly described in America in 1889 by Smith and Kilborne. In this country two definite forms are known, viz. :—*B.* (or *babesia*) *bigeminum* and *P. divergens,* both of which are introduced into the blood stream by ticks which are themselves infected. *P. bigeminum* is the commonest parasite, and its inoculability to healthy cattle by means of ticks was experimentally proved by M'Fadyean and Stockman in 1908. The existence of *P. divergens* was described by M'Fadyean and Stockman in 1911.†

Being tick-conveyed, it follows that the disease occurs where infected ticks thrive, such as on rough pastures, moors or any coarse ground which will afford good harbourage for these parasites. Low-lying farms situated in what are known locally as " bottoms," which are sheltered from drying winds and have moist soil, and which are more or less overgrown with rank herbage and bushes are well known as redwater sites. The presence of ticks even in great numbers and under the best of conditions for these parasites does not necessarily imply that the cattle grazing there will become infected with redwater, for if the ticks are clean no apparent harm results. For the disease to follow, the ticks themselves must be

* *Annual Report,* C.V.O., Bd. of Agric., 1913.

† *Journ. Comp. Path.,* 1911, Vol. XXIV., p. 340.

infected, and fortunately at present in the United Kingdom the ticks are only infected in certain districts.

Redwater appears in the spring and again in the autumn. The disease occurs chiefly in adult cattle, though calves and yearlings may be attacked. Calves in most cases only show slight symptoms, though they are capable of becoming infected by inoculation. As in the cases of other protozoan diseases, *P. bigeminum* is only capable of causing infection in the ox or in nearly-related species, *e.g.*, deer and buffaloes.

The period of incubation is generally from 6 to 10 days following direct inoculation into the blood, but with natural infection, such as occurs in the field, the period is a fortnight or even longer.

One attack confers a high degree of immunity, but infected animals harbour parasites in their blood possibly for several years, and herein lies the difficulty in stamping out the disease and preventing its spread. Though such cattle may themselves be apparently healthy they are quite capable of infecting ticks, and so the disease may be perpetuated in an already contaminated locality and may also be spread to fresh pastures. Animals reared on redwater farms are therefore immune, or more correctly stated, tolerant, but are at the same time dangerous carriers. The mortality varies greatly; Craig considers it probably less than 5 per cent.* Relapses after apparent recovery from one attack are not infrequent, these occurring especially at times at which the vitality may be lowered, *e.g.*, following parturition.

The ticks responsible for the transmission of piroplasms in this country are the *Ixodes ricinus* (or *reduvius*) and *Hæmaphysalis punctata*. These ticks in their life history pass through certain stages, namely, egg, larva, nymph and adult. The larval form after leaving the egg attaches itself to a bovine and after sucking blood for a time drops off, moults and becomes a nymph. The latter becomes attached to a second bovine and goes through the same process, the adult form finally making its way on to the body of a third host. These ticks are known as non-continuous feeders. The adult form is sexually differentiated; the males do not suck blood, but after fertilising the females, drop off and die. A proper understanding of the life cycle and habits of these ticks is essential before dealing with preventive measures, since the suppression of redwater is necessarily bound up with the eradication of infected ticks. The subject has been largely studied in Great Britain by Stockman.† The life-cycle of *I. ricinus* occupies at the

* Wallis-Hoare, *System. Vet. Med.*, 1913, Vol. I., p. 1008.

† *Annual Report,* Proc. Dis. Animals Act, 1910.

very least 22 weeks, made up as follows:—egg-laying 1 week, hatching out of larvæ 6 weeks, moulting of larvæ 4 weeks, nymphs to adults 8 weeks, attachment of adult ticks 1 week, and to this one must add the few days before larvæ are capable of attaching themselves and the few days' attachment of larvæ and nymphs. As a rule, the period will be longer than this owing to cold weather, which has a slowing effect, and to the time (variable of course) before the tick happens to find a host.

The life-cycle of *Hæmaphysalis punctata* is similar, but the time occupied by the individual stages is somewhat longer. Stockman found that the minimum period during which all stages could be passed was 94 days made up thus:—egg laying 10 days, hatching 38 days, larvæ resting 3 days, larvæ engorged in 5 days, larvæ moulted in 14 days, nymphs resting for 3 days, nymphs engorged in 4 days, nymphs moulted in 7 days, adults resting for 4 days, adults engorged in 6 days. The usual cycle probably lasts about 160 days, and there is as a rule only one generation per annum. Hatching of eggs mostly occurs in July and, to a less extent, in August; moulting of larvæ to nymphs mostly takes place in August and September and less in October, and many of the latter engorge during the same months. A large proportion of nymphs moult to adults from September onwards, and pass the winter thus, but many do not become engorged or moult, as the case may be, until the following spring or later. The latter supply the large number of adults found to have become engorged in April and May. Laying of eggs chiefly occurs in May and June. Adults are thus most numerous in spring and early summer and in autumn, or at the times at which redwater is most prevalent.

Preventive Measures.—The prevention of bovine piroplasmosis may be partially effected by reducing the number of ticks, and this can be done by cleaning and draining the land and where possible tilling it, though in many districts and on many tick-infected pastures it is impossible to convert the grazing into tillage. Cleaning and draining, however, will do a lot to free the land from ticks. A top dressing of lime or salt is also recommended, at the rate of 3 tons of the former or ½ a ton of the latter per acre. If it is impracticable to thoroughly clean the land of ticks, this should be done as well as may be and cattle should then be kept off such pastures for two years. It is a positive advantage to graze sheep on redwater land as ticks become cleansed of infection by feeding on sheep. It must, however, be remembered that by returning "carrier" cattle to purified ground one simply re-introduces the disease. If it is impracticable to keep cattle off the pastures, one may at least

run on sheep at the same time. Many infected ticks will then be diverted from their natural hosts, and the number of cases of redwater will be likely to decrease.*

One may get rid of large numbers of ticks by dipping the cattle or sheep in arsenical solutions, and the best time to do this is April and May and October and November, *i.e.*, at periods when adult ticks are attached. The reasons why it is preferable to dip at these times is (*a*) on account of the fact that one is thus catching the tick before it lays eggs; (*b*) owing to the fact that the period of attachment is longer in the adult stage than in any other. Cattle may be solidly protected by inoculation with blood from a recovered adult or from an experimentally infected calf which has passed through an attack. The operation is practically without danger for animals under one year old, and even in those older is not so serious as a natural attack. The difficulty is to fix a suitable dose of infective blood, and the method cannot be considered safe for valuable animals over two years of age or for animals which are not in a good state of health. Animals should be kept indoors for a fortnight or three weeks after they have been inoculated.

COCCIDIOSIS.

Coccidiosis (psorospermosis) is a disease which affects several different species of domesticated animals and is due to protozoan parasites known as coccidia. The life-cycle of these parasites is somewhat complex, but so far as is known no intermediate host is necessary. In common with many other classes of protozoan parasites coccidia have their own particular hosts, *i.e.*, they are pathogenic only for one species of animal or for an allied species. Thus rabbit coccidia are capable of producing disease in hares, the fowl coccidium is capable of infecting pheasants. On the other hand the rabbit coccidium does not produce disease in the ox. The parasites multiply enormously in the intestinal epithelium and in the case of some animals in the parenchymatous cells of the liver. The chief symptoms of coccidiosis, therefore, are diarrhœa and emaciation.

Coccidia are known to be parasitic in cattle, rabbits, sheep and birds. No authentic case has been described in the horse. The disease has been recorded in other mammals, including the goat, dog, cat, mouse, and also in man. The young of all animals are more liable to attack than are adults.

Coccidiosis of the Rabbit.—The coccidium is known as *Cocci-*

* *Annual Report,* C.V.O., Bd. of Agric., 1908.

dium cuniculi. Probably more work has been done with this coccidium than with any other, chiefly for the reason that the disease in rabbits is very widespread, occurring both among domesticated and wild rabbits, but especially among the former.

Coccidiosis of Cattle (red dysentery).—Due to *Coccidium zürni.* The etiological significance of coccidia with regard to this disease of cattle was first pointed out in 1892 by Zschokke,* but the parasite had been previously noted by Zürn in 1878. In Great Britain the first cases were recorded by Gair† in 1898 and later by the author‡ in north Devon in 1913. It is also known to occur in Cornwall and in Ireland, and is probably not uncommon in other parts of the country. The disease usually attacks cattle when from 6 months to 2 years of age, though in Gair's cases adult milch cows were also attacked. The author has not seen it in cattle which were more than 18 months of age, even though such adult cattle were grazing in the same fields as the affected animals, neither could coccidia be found in their fæces. The course of the disease is variable. Zschokke, in Switzerland, found that sometimes all symptoms disappeared in 5 to 10 days, though sometimes the disease lasted for weeks and was accompanied by great emaciation. The incubation period has been fixed by Degoix§ at from 1 to 2 months, which was the time elapsing between the turning out of healthy animals into infected pastures and the moment at which symptoms appeared. In experimental cases the period of incubation has been found to be about 3 weeks. Outbreaks sometimes reappear year after year on certain pastures (Degoix). The disease is essentially a summer one, cases chiefly occurring in July and August and, to a much less extent, in September, though Gair, on farms where it reappeared, has noticed it as early as April. It is especially to be met with in low-lying damp pastures. The method of infection is by ingestion. Though it is easy to understand why the disease spreads among cattle in the same herd or in the same district, it is difficult in certain instances to say how the disease arises. The purchase of infected stock is doubtless a common method, but the author has been able to exclude this means and has not been able to trace the origin of certain outbreaks. A more careful routine examination of the fæces of diarrhœic bovine patients might reveal unsuspected cases of the disease, and thus throw some light on its transmission. The mortality from the disease is very variable. Zschokke noted

* *Journ. Comp. Path.*, Vol. V., p. 101, Trans.

† *Journ. Comp. Path.*, 1898, Vol. XI., p. 171.

‡ *Vet. Rec.*, 1913, Vol. XXVI., p. 71.

§ *Journ. Comp. Path.*, 1904, Vol. XVII., p. 91.

6 deaths among 59 cases, while Gair noted 6 deaths among 10 animals affected.

Coccidiosis of the Sheep. — Due to *Coccidium faurei.* The occurrence of the disease was first recorded in Great Britain amongst lambs by M'Fadyean.* In the outbreak described 10 per cent. of the lambs had died within a month, death generally occurring about 48 hours after the onset of symptoms. The ewes were apparently resistant. Sheep are possibly more frequent sufferers than is commonly supposed. According to Eckardt the mortality is 60 to 70 per cent.

Coccidiosis of Birds.—Fowls, ducks, geese, turkeys, pigeons, grouse and pheasants are occasional victims, but the disease occurs in many other species, both wild and caged. The parasite is named *Coccidium tenellum* and, as with mammals, the disease is chiefly associated with youth. The eggs of infected birds are said to carry coccidia.

PREVENTIVE MEASURES.—These are not easy owing to the great resistance of the parasite. Oocysts are not infective at the moment of discharge and generally do not become so for about 3 days (rabbit coccidium).

Should this disease appear among grazing cattle they should be removed at once to a suitable shed and isolated. This measure is not only necessary for therapeutic reasons but in order that the highly infective fæces may be kept from the fields and streams, and that they may be readily collected and destroyed. Though one is often inclined to return convalescent patients to pasture, the greatest care should be taken that the risk of spreading the coccidia is made as slight as possible. It would be distinctly advantageous to carry out microscopic examinations of fæces from patients for a period before they are again turned out to pasture. All the dung from the shed that has housed infected cattle should be mixed with an abundance of quicklime and destroyed or put on arable land. If the disease is known to be in the district care must be taken to avoid purchasing young stock from farms which may possibly be infected. If practicable young animals should be kept off pastures which are known to be infected from June to September, and during these months they may be used for sheep.

Owing to the great prevalence of coccidiosis among wild rabbits and considering their migratory habits, one cannot make any feasible suggestions for the eradication or even the prevention of the spread of the disease. This also applies to game birds, but at

* *Journ. Comp. Path.,* 1896, Vol. IX., p. 31.

any rate some endeavour should be made in purchasing fresh stock to ensure that they come from clean districts.

Among housed rabbits and domestic birds cleanliness and attention to ordinary hygienic requirements, such as providing clean water, food, and housing accommodation, will do much to lessen the risk of the disease propagating.

With regard to the fowl coccidium, it is stated that the parasite is capable of retaining its vitality for 12 months and possibly longer after being voided from the body. As it is practically impossible to disinfect the poultry run, one might transfer the birds to fresh ground, but this will only have the effect of spreading infection. In any case, it is advisable to remove and burn, if possible, the top 3 inches of soil. It is best, therefore, to leave the birds where they are and to kill any showing symptoms. Only newly hatched chicks should be placed on clean ground, and all coops, roosts, &c., should be disinfected or, better, burnt. It is said to be a good plan to dip eggs into 90 per cent. alcohol before being set in order to kill any coccidia adhering to the shell. Only healthy hens should be used for setting.

MALTA FEVER.

Malta Fever (Mediterranean fever, Rock fever, Naples fever, Levant fever) is a contagious disease common to practically all domesticated animals and man and is due to the *Micrococcus melitensis,* discovered by Bruce in 1887. The disease was first described by Marston in 1859, who saw many cases in Malta. Since 1879 it has been recognised at nearly all points of the Mediterranean littoral, in France, and in many other parts of the world.

A Commission was appointed by the Government in 1904 to investigate the disease, and the chief source of infection to man was found to be goats' milk.

Malta fever is chiefly seen in the goat, in which a frequent symptom is abortion, but the disease is not infrequent in the sheep. Zammit* in 1905 found 10 per cent. of the goats at Malta to be excreting the organism with their milk, but serum tests showed as many as 50 per cent. to be actually infected. The disease occurs more rarely in horses, mules, large ruminants, dogs and cats. Fowls show a marked susceptibility, but are only exceptionally attacked in nature. Very many cases have been seen in man. The age and breed of animals exerts no influence on infection. The organism, which is most probably obligatory, is excreted from the body, especially in the milk and urine, though in the case of the

* Hutyra and Marek, *Special Path.,* Vol. I., p. 197.

milk the excretion is often intermittent. In the goat and sheep infection chiefly occurs by ingestion of milk or urine of affected animals, chiefly the latter, and this may also be derived from infected persons. There is a good deal of evidence to show that in the case of goats the disease may be transmitted by copulation. In other animals infection also usually takes place by ingestion of virulent excretions, but in the horse and mule infection may occur by inoculation of the virus through skin wounds due to the animal having lain on contaminated bedding. Small rodents may become infected by feeding on contaminated material. The disease in goats is frequently spread from animal to animal through the agency of the milker. The micrococcus can live for several months in a cool, dark place, but rapidly dies at 15° to 25° C when exposed to light. It is capable of remaining alive for 69 days in dry sterile manure, and for 7 weeks in urine. It is easily destroyed by heat and disinfectants, thus heating of milk to 68° C for 10 minutes is sufficient to sterilize it.

The mortality from the disease is low, and in man it is only fatal in about 3 per cent. of the cases.*

Preventive Measures.—Several factors combine to render the suppression of Malta fever rather a difficult undertaking. The disease is very liable to be disseminated through the agency of small rodents, and new centres may thus be created.

In order to prevent the introduction of the disease into a clean herd make sure that imported animals do not come from a herd in which cases of abortion have occurred. If no knowledge can be gained on this point, the animal should be quarantined until parturition has occurred. Once the disease has become established in a herd it is very difficult to eradicate it. All animals which abort must be isolated and measures taken to destroy the fœtus and its membranes, and to disinfect the floor, walls, &c. Submit all the animals to serum tests, and those which react positively must be considered infective for long periods. Often the quickest way of dealing with the disease would be to slaughter out and restock if possible with healthy animals.

The suppression of the disease in man is not so difficult, inasmuch as infection from man to man very rarely, if ever, occurs. The milk from goats in infected localities should always be heated before being taken. The success of measures such as these was evident during outbreaks among British soldiers in Malta in 1906.

* Hutyra and Marek, *Spec. Path.*, Vol. I., p. 196.

MAMMITIS.

All the domesticated mammals are at times affected with mammitis (mastitis), but the condition is by far most frequently met with in the cow. The name is given to an inflammation affecting one or more quarters of the mammary gland.

Bovine mammitis is produced by the invasion of the mammary gland by various micro-organisms, and the cause may be acute or chronic. Streptococci are most commonly associated with bovine mammitis, though other organisms, *e.g.*, staphylococci, bacillus coli, &c., are occasionally responsible. Carré* has described a bacillus somewhat resembling the bacillus of swine erysipelas which he isolated from several cases of mammitis. Mammitis of a chronic type may be produced by the tubercle bacillus or by the actinomyces. The prevalence of mammitis among dairy cows is shown by Savage† who, quoting from the veterinary inspector's report on the examination of cows in London cowsheds, says that ·9 per cent. of the cows at the time of inspection were suffering from acute mammitis, and that 3·7 per cent. showed atrophy of one or more quarters, these figures being the means of various inspections carried out during the year 1908. Investigators from time to time have pointed out the frequency with which micro-organisms are found in the milk coming from healthy udders. Mathers‡ states that virulent hæmolytic streptococci may grow and multiply in the milk ducts of a cow without causing any visible changes in the udder, and that milk containing them may produce cases of acute tonsilitis in man. Savage investigated the frequency of the occurrence of the streptococci of mammitis in quarters apparently healthy. He found that in 84 per cent. of the cases in which less than four quarters were affected, identical organisms were present in one or more of the apparently healthy quarters. This is of somewhat considerable importance to the medical practitioner when one considers the frequency with which the milk from apparently sound quarters is mixed with the general milk. Though the risk to human life is not negligible there has been, however, a great tendency in some quarters in the past to exaggerate this risk. Thus on the very slenderest of evidence some observers have ascribed outbreaks of human sore throat to the drinking of milk from cows presenting certain lesions on the teats. In the same way sore throat has been attributed to the drinking of milk from cows affected with mam-

* *Revue Vet.*, 1907, p. 561.

† *Milk and Public Health*, 1912.

‡ *Jl. Inf. Dis.*, Vol. XIX.

mitis. The researches of Savage have shown that the streptococcus commonly found in cases of sore throat, though similar morphologically, &c., possesses several points of difference from the streptococcus commonly associated with bovine mastitis. The disease is an important one not only from the possible danger to human beings, but also from the loss of milk and depreciation in the value of the cow owing to the fact that the affected quarter rarely, if ever, regains its normal usefulness.

Outbreaks of mammitis of a marked contagious nature have been reported on many occasions, the type of the disease being usually chronic. This form of mammitis is also produced by streptococci. At times the first indication that there is anything wrong is received from the person purchasing the milk. In early cases the milk may appear to be normal on leaving the udder, but on standing it shows a curdy deposit and may give off a rather offensive odour. As the disease progresses the deposit becomes much more abundant, and the supernatant liquid becomes wheylike. This state of affairs usually follows the introduction of a fresh purchase, and the disease may have spread to several other cows before its existence is realised. In one such outbreak described by Radway* the disease was so persistent that it was only eradicated by slaughtering all the milking cows and thoroughly disinfecting the byres.

The mortality is variable, often being very high in some outbreaks of acute mammitis. The period of incubation varies according to the type of the disease. It may be only 2 or 3 days in acute mammitis, while in chronic mammitis it may be as many months (Begg).† The disease results from direct inoculation of the udder with pathogenic organisms and is frequently spread by the hands of the milker. Except in cases of tuberculous mammitis, the inflammatory condition of the udder is thus a primary one. As Begg points out,‡ it is surprising that mammitis is not more common. The udder is a highly vascular organ and is subject to traumatism from tramps and horn gores; too frequently it is caked with dung and is often in constant contact with fæces and urine, or with purulent discharges derived from the uterus or drawn from a diseased quarter. It is delicate in structure, and is easily injured. Lastly, the milk in the sinuses is an excellent culture medium and at an ideal temperature for bacterial growth. Begg draws attention to the connection between suppurating sores on the feet of cattle

* *Journ. Comp. Path.*, 1902, Vol. XV., p. 361.

† Wallis-Hoare, *System. Vet. Med.*, 1913, Vol. I., p. 387.

‡ Wallis-Hoare, *System. Vet. Med.*, 1913, Vol. I., p. 375.

and mammitis. The use of teat syphons on cows hard to milk has been often blamed for causing mammitis, and knitting needles and even straws picked up from the floor of the byre are sometimes used for enlarging the teat canal. Cows in full milk are more susceptible to infection than those in a dry or a semi-dry condition owing to increased vascularity of the udder, and to the fact that the teats in many cases are more patent. Both dry cows and virgin heifers do, however, become affected with mammitis, and in the West of England the author has frequently seen the disease in the latter class of stock while at grass. One fact which is well recognised is that the entrance of bacteria into the udder is facilitated by the teat canal being left full of milk often with a drop still dependent from the orifice.

Predisposing causes of mastitis are an unsanitary condition of the byre, whereby the animals have to lie in filth and the udders are seldom, if ever, clean, and any condition which would lower the animal's natural powers of resistance. Draughts, especially if toward the cow's hindquarters, are commonly held responsible for the diseased conditions of the udder, but in this connection it must be remembered that draughts, entering the cowshed beneath an ill-fitting door, for instance, are more noticeable and have a more pronounced effect in byres in which a too high temperature is maintained, and in which the atmosphere is foul and moist. Where the internal temperature is maintained only a few degrees above that prevailing outside, draughts are not so appreciable.

Preventive Measures. — The byre must be constructed on approved lines so that the cows can lie down in comfort and yet keep their udders clean. Udders should be wiped over with a clean, damp cloth both before and after milking, and at the end of milking the teat must be left free from milk. There is no reason why the udder, or at least the teat, should not be wiped over with a cloth rung out in some mild and non-irritating disinfectant such as lysol. Under no circumstances should the fore milk be milked on to the floor of the byre, and the practice so frequently seen of milking out a diseased udder on to the straw should be strongly condemned.

The restricted housing accommodation found on all farms and dairies too frequently precludes the possibility of isolating infected animals or those with any suppurating sores or such as have not properly cleansed. Nevertheless, cases should be isolated where opportunity exists. A milker should not attend to sick animals, especially to such as have sores or purulent discharges. If practicable, milking in the byre should be abolished, and a proper milking shed provided.

Cleanliness in connection with milkers and milking, cows and houses would undoubtedly reduce the incidence of mammitis. In outbreaks of the form of chronic mammitis, in which contagion appears to play the greatest part in spread, one should carry out isolation of the affected, and these should have separate milkers. If circumstances do not allow this, the diseased animals should be stalled together and should be milked last. Milkers must wash both their hands and the udder after milking. Litter from beneath infected cows should be burnt or mixed with chloride of lime. New purchases should be quarantined for about a fortnight if possible.

MILK FEVER.

This is an afebrile condition occurring usually within a day or two of parturition, the chief symptom being complete loss of consciousness. Many theories have been brought forward to explain the etiology of milk fever, but at the present time the origin of the disease still remains obscure. It is by far most frequently met with in cows, though the condition is said to occur in rare instances in the goat and sow. Cows of all ages are susceptible, but mostly so at the third to fifth calving, *i.e.*, during the period when they are considered to yield the greatest amount of milk with the highest percentage of fat. Eckles and Palmer* have shown, however, that the variation in the fat content is not such as is generally supposed. A plethoric condition resulting from too heavy feeding and too little exercise before the full time of gestation is usually put forward as a predisposing cause. With regard to this we have only to say that we have frequently observed the disease when every precaution was taken to avoid a condition of plethora. Cases are also said to occur most commonly after an easy birth.

The onset of the disease is as a rule very rapid, and when recovery occurs this is equally rapid even in some cases in which no treatment has been applied. With modern treatment and prompt attention the mortality to-day is low; probably less than 3 per cent.

From our experience it appears that little can be done to prevent the occurrence of milk fever. Too heavy feeding and insufficient exercise before calving should be avoided. It is important to avoid milking the cow too soon after calving. One should remove small quantities of milk from the udder at frequent intervals and avoid emptying the udder completely. Nevertheless, most practitioners have encountered cases of milk fever before milking had begun,

* *Journ. Agric. Res.*, 1917, XI., No. 12, p. 645-648.

and indeed before the act of parturition had even commenced. So far preventive measures embracing all the supposed predisposing causes have not given much success.

SCRAPIE.

This disease of sheep is most frequently associated with intense irritability of the skin, and sometimes nervous symptoms. In Great Britain at the present time it appears to be enzootic in the extreme north of England and south of Scotland, though the same disease has also been described in parts of Germany and France. Scrapie has been investigated during recent years by M'Fadyean, Stockman and others, and though light has been shed upon many points regarding the occurrence of the disease there are still many questions which will only be solved by patient research. Though essentially a disease of sheep, it has been alleged to occur in goats. According to Stockman, it was probably first brought to England in the latter part of the eighteenth century by Merino sheep imported from Spain or Saxony, and for a time existed in Norfolk, from which county it spread towards the north. Within the regions in which scrapie at present exists the disease is probably somewhat irregularly distributed, and it occurs especially among the large flocks kept on hill pastures. Probably no breed of sheep is insusceptible. It is seldom seen in animals under 18 months of age, no doubt owing to its extremely long period of incubation, but adult sheep of any age may be attacked. It seems most commonly to occur among 2 year old ewes, and frequently at about the lambing season. The course of the disease is somewhat chronic, cases usually lasting about 3 or 4 months, and few animals appear to recover. According to Stockman the common percentage of loss in infected flocks is 4 per cent. per annum, though it may be higher. Many different theories as to the cause have been brought forward. M'Gowan considers scrapie to be due to *sarcosporidia,* but the evidence is meagre in the extreme, and at the present moment the etiology is most obscure. Though it seems likely that the disease is a microparasitic one and is spread by contagion, no one has yet been able to transmit it either by experimental inoculation or by contact, or to demonstrate the existence of the virus. The possibility should be noted that infection may occur in lambs before birth as well as after. In M'Fadyean's experiments out of 11 lambs born of infected ewes only 2 developed scrapie. Stockman has recorded cases in which the disease has been introduced into healthy flocks by rams from an infected flock.

PREVENTIVE MEASURES.—So far as can be said at present, the only satisfactory way in which the disease can be eradicated appears to be by the sale of the whole flock and re-stocking. Even so it is difficult to ensure that one is re-stocking with clean animals. Other measures are likely to fail since the disease cannot be diagnosed in individual animals in early stages. In some cases it may be possible to gradually replace the affected stock with healthy animals by keeping flocks separate. It is necessary to avoid using tups from the infected flocks among clean animals as Stockman has collected a good deal of evidence to show that tups may disseminate infection by copulation. Affected sheep should be at once slaughtered as they may then be used for food.

BRAXY.

Braxy (bradsot) has been frequently confounded in the past with black-quarter and anthrax. It is a very acute and rapidly fatal disease affecting sheep in many parts of the world, *e.g.*, Scotland, Iceland, Norway and Denmark, Germany, &c. It has been enzootic in Scotland since early times, though certain districts (Aberdeenshire and Forfarshire) are said to be free.

There has been a good deal of controversy regarding the etiology of the disease, and at the time of writing this still remains obscure. According to many observers (Hamilton, Jensen, Gilruth) braxy is caused by an anærobic organism which was first described by Nielson in 1888, and which resembles in some respects the black-quarter bacillus. It is to be found in the lesions which are said to be constantly present in the abomasum. The disease cannot be transmitted to healthy sheep by feeding with cultures of this organism or with material obtained from dead sheep. In consequence of this and also for other reasons Titze and Weichel, Miessner, Dodd and others deny that the so-called braxy or bradsot bacillus is the real cause, stating that it is merely a post-mortem invader. According to Hamilton the disease is especially prevalent in late autumn and winter, and first year's animals are more liable than adults, but it is rare before weaning. Until more definite information is to hand regarding this disease, it is difficult to formulate measures to be adopted with a view to prophylaxis.

LOUPING-ILL.

Louping-Ill (trembling) is a disease affecting sheep in Scotland and north of England. It is a non-febrile or only slightly febrile

disease showing itself either as a passing indisposition or less frequently by symptoms of nervous excitability followed by paralysis and death. During recent years Stockman has studied the disease and gone a long way towards clearing up many obscure points with regard to its natural transmission, &c. As to its etiology, Stockman has demonstrated the existence of "chromatin bodies" resembling protozoa in certain lymphatic glands and in the blood of affected sheep and, so far as can be said at present, it seems to be probable that these bodies are the actual parasites of the disease. Louping-ill can be transmitted to healthy sheep by the inoculation of blood and lymphatic gland juice containing these bodies, and natural transmission occurs by means of ticks (*Ixodes ricinus*). Stockman has transmitted the disease to healthy sheep by means of adult and larval ticks which in their previous stages had fed on animals affected with louping-ill, and thus the infective agent has been proved to pass through the egg. The blood of a recovered sheep is no longer infective by inoculation, but such an animal has a considerable degree of immunity. The disease occurs on certain farms, so-called "louping-ill farms," and has a definite seasonal incidence, chiefly April, May and early June, and less in autumn, while a few cases are seen at any time of the year.

PREVENTIVE MEASURES.—It is difficult at the moment to suggest really practical measures to be put into operation against louping-ill since some points in the epizootiology of the disease are still obscure. Since the disease is tick-borne, however, it is obvious that one of the chief problems is the destruction of infected ticks. It is likely that the incidence of the disease may be considerably lessened by heavily stocking infected pastures, and dipping frequently, *e.g.*, at 5 day intervals.

Such measures should be put into operation during the louping-ill seasons as it is at this time of the year that one is most likely to catch the largest number of ticks.

FELINE DIPHTHERIA.

This disease is described by H. Gray* as "a contagious one of the cat, characterised by the presence of diphtheritic membranes on the fauces, pharynx or larynx, and due to some micro-organism not yet determined."

Though no connection between feline and human diphtheria has been proved, it would nevertheless be advisable to strictly isolate cats showing symptoms of the disease, and owing to the

* Wallis-Hoare, *System. Vet. Med.*, 1913, Vol. I., p. 317.

high rate of mortality the question of treatment or destruction might be decided in favour of the latter.

Medical Officers of Health and others have frequently asserted that human, feline and avian diphtheria are identical diseases and caused by the Klebs-Löffler bacillus. It is consequently urged by some medical authorities that human beings can contract diphtheria from cats, birds, and some say from cattle. The evidence has been carefully sifted by Gofton, and as a result one is forced to conclude that there are no grounds for the assumption that true diphtheria occurs in the lower animals. At the same time the fact is not to be denied that diphtheria may be spread through the agency of milk. The important point is that the cow is to be incriminated as an entirely passive carrier.

HÆMOGLOBINURIA.

Hæmoglobinuria (azoturia) is an acute specific disease of horses, accompanied by the excretion of large quantities of hæmoglobin in the urine. The disease occurs under certain definite circumstances which have been recognised by most observers as being nearly if not quite constant, and which are as follows :—No horse in regular work is ever attacked. As a rule the horse has been kept at work daily for some time and has been receiving a full ration. For some reason other than illness he is rested for some days while the full ration is maintained. As soon as the animal is again put to work, perhaps only a few minutes after he is taken out of the stable, he is attacked by stiffness of the muscles of certain parts of the body, usually in the hindquarters. These symptoms are often quickly followed by collapse and inability to rise. Urine which is subsequently passed is then found to contain hæmoglobin in larger or smaller quantities.

Numerous theories have been brought forward with the object of explaining the occurrence of the disease. It is beyond the scope of this work to describe them in detail, but the researches of M'Fadyean* on the subject are well worthy of consideration. Stated briefly, the opinions of M'Fadyean are as follows :—During the time that the animal is being worked and receiving a working diet there is a certain production of red blood corpuscles accompanied by an equal destruction. When the animal is rested, however, the destruction is diminished while the production goes on as before. The number of red corpuscles thus mounts up to higher than normal. As soon as the animal is put to work again an increased destruction

* *Journ. Comp. Path.*, 1888, Vol. I., p. 1, and 1893, Vol. VI., p. 245.

of red corpuscles occurs almost immediately, with the result that the hæmoglobin cannot be got rid of quickly enough in the usual way and the excretion therefore falls upon the kidneys. The lesions in the muscles result from embolism of certain vessels produced by the liberated hæmoglobin. The course of the disease is variable. M'Fadyean estimates the mortality at about 50 per cent. It appears to be more common in winter, but M'Fadyean states that this is probably solely because horses are given short rests more frequently in the winter than in the summer. Cases are said to be more often observed in the heavier types of horses.

The disease can certainly be prevented by avoiding the circumstances in which horses are attacked. Work should, if possible, be regular. If idleness is enforced a certain amount of exercise should be given, and the diet should be restricted to maintenance requirements. If there is need to increase or improve the condition of a horse that is resting the addition to the maintenance diet should be in the form of carbohydrates and not of proteins. A sufficiency of protein for the repair of wasted muscles, which repair it is desirable to effect during the resting period, may be brought about without fear of overloading the comparatively resting muscles on a ration having a nitrogenous ratio not narrower than 1 to 8.

Whether the non-protein nitrogenous substances have the same pathological effect when given in abundance, as is the case with true proteins, is, we believe, not yet known.

LYMPHANGITIS.

The so-called "lymphangitis" of plethora, as distinguished from the specific lymphangitis due to cryptococci, &c., is a disease commonly met with in heavy cart horses of a dull phlegmatic temperament. The onset of the disease usually occurs after a few days' rest in the stable and, it is alleged, is then due to excessive feeding during this idle period, and especially upon foods containing a high proportion of protein. Few will deny that lymphangitis does usually occur after a rest following on a period of bodily exertion but that the disease is always associated with heavy feeding the author, for one, does not agree, having seen it occur repeatedly among city dray horses which were light in weight for their size and were not fed on an excessive diet with a narrow nitrogenous ratio. Even when one took into consideration the intermittent character of the work the food given was not excessive, neither was it unbalanced. Too much food, and especially food of a nitrogenous character, during a period of rest when the horse should

receive nothing more than a maintenance diet, no doubt aggravates and precipitates the pathological condition known as "lymphangitis," but it would appear that sudden cessation of work is the primary factor.

The disease may be prevented by providing regular work and by giving during the week-end rest a maintenance diet having a nitrogenous ratio not narrower than 1 to 8. The administration of a dose of sodium sulphate or other suitable laxative on the Saturday would be beneficial in removing waste products from the circulation of lymphatic animals, and so act as a substitute for the denied exercise.

GREASE, MUD FEVER AND CRACKED HEELS.

Mud fever and cracked heels may be described as inflammatory conditions of the skin in the region of the heels and on the flexor aspects of the limbs, and at times leading to the more chronic disorder known as "grease."

Mud fever and cracked heels are common in well-bred horses, while grease is more frequently seen in heavy animals. Probably with the latter simple cracked heels escape notice and these becoming infected the chronic form or grease results. Horses with a sluggish lymph circulation are more prone to grease than are animals with a quicker and more vigorous temperament.

The cause of these conditions is to be found chiefly in exposure to wet coupled with a cold wind. Frequent washing of the legs, especially with soft soap which is with difficulty removed, predisposes to a cracked condition of the skin. Other agencies which are at times alleged to have some connection with the causation of these disorders are the chemical nature of the soil and a lack of pigment, with consequent action upon the skin of ultraviolet light rays.

Horses returning from work with their legs wet and caked in mud should have them bandaged so that the mud dries with the exclusion of air. Next morning the mud can be readily removed by brushing. The legs should on no account be washed. With heavy cart horses in a commercial stable the application of woollen bandages is not always practicable. Straw bandages are excellent for drying the legs and keeping them warm, but have the great disadvantage that many horses will not rest with them on. It is important to see that such bandages are properly adjusted, otherwise the animals are unable to lie down.

DIABETES INSIPIDUS. POLYURIA.

The terms "diabetes insipidus" and "polyuria" are employed by some observers (Hutyra and Marek) as designations for somewhat different conditions, the symptoms of "polyuria" being similar to those of "diabetes insipidus," but are quite transitory in nature. By others the terms are used synonymously.

Diabetes insipidus of the horse, due to feeding on fodder, grains or hays that are in a state of fermentation, is a disease which has received relatively little attention from the scientific investigator, and, so far as the author knows, no serious attempt has been made to discover its real cause. Such hay or grain which is musty or mowburnt, *i.e.*, which has fermented, produces a greatly increased secretion of urine, of pale colour and lower specific gravity than normal, but free from albumen and sugar. There is great thirst and emaciation is rapid, and if the damaged food is given persistently the animal becomes weak and languid.

A similar train of symptoms is sometimes present in the course of certain chronic contagious disorders, *e.g.*, glanders and tuberculosis. In the case of diabetes insipidus, due to fermented fodder, the symptoms ameliorate when the harmful food is omitted from the ration, but no benefit ensues until this is done. Musty oats are more deleterious than mowburnt hay; indeed, the latter may be given with safety if it is introduced into the dietary cautiously.

Speculation as to the actual causative agent is idle; it may be found in the products of carbohydrate fermentation or, what is probably more likely, among the amino-acids resulting from disintegration of protein.

DISEASES AFFECTING POULTRY.

The diseases of poultry which demand notice are the following:—fowl cholera, avian diphtheria, epithelioma contagiosum, fowl plague and fowl typhoid.

The three diseases first mentioned are seen in Great Britain, while the remaining two (fowl plague and fowl typhoid) have not been described in these islands up to the present.

FOWL CHOLERA.—Fowl cholera is caused by an organism of the pasteurella type. The disease is very acute and infectious, and outbreaks occasionally occur not only in the fowl but also amongst other birds of the farmyard, including pigeons. The virulence of the organism in nature varies considerably and some strains appear

to show a greater degree of virulence for some species of birds than for others. Thus outbreaks have been noted in which the disease spreads more amongst one species of bird than amongst others, and so the terms "duck cholera," "goose cholera," &c., have come into use. None of the domesticated mammals is susceptible. Though bacteriological evidence indicates that the fowl cholera bacillus may exist as a saprophyte on the earth's surface, in temperate countries the organism can be looked upon as obligatory and, in consequence, sporadic cases do not occur. During 1900 two outbreaks occurred simultaneously in this country on two farms several miles apart, and it was thought that infection was possibly introduced by foreign corn sweepings. The method of infection is by ingestion of the virus, which is always present in the diarrhœic fæces. The disease is chiefly spread in this way, and virulent material may be transported by persons' boots, by dogs and other animals, and by small birds. One cannot always discover the cause of the first case in an outbreak, though infection is frequently introduced by a newly purchased bird. The organism remains alive in manure for at least 3 months (Gärtner) also in putrefying carcases and in garden soil (Kitt).* Desiccation and light, however, have a rapid and destructive influence, *e.g.*, in exudate exposed to sunlight and air the virulence was lost in 48 hours. The period of incubation was found by Ostertag and Ackermann† to be 4 to 9 days in chickens which had received one meal from the organs of a fowl dead of cholera. The duration is 1 to 3 days in most acute cases, but exceptionally it may be 7 to 12 days.

The mortality is very high, and the disease very quickly clears out the poultry yard. Pasteur introduced a method of vaccination which, however, has not been very largely practised partly because at times it may be dangerous and partly on account of the rapid spread of the disease. The method consists in the use of attenuated cultures.

Fowl Plague. — Fowl plague due to an ultravisible virus is somewhat similar clinically to fowl cholera, though as a rule tending to run a rather more chronic course, the affected birds sometimes showing nervous symptoms. Fowl plague was first described in 1878 in Italy by Perroncito, and the cause elucidated by Centanni and Savonuzzi‡ in 1901. Between 1894 and 1900 it existed in various parts of Italy as an epizootic, but extensive outbreaks have

* Hutyra and Marek, *Spec. Path.*, Vol. I., p. 88, Trans.

† Hutyra and Marek, *Spec. Path.*, Vol. I., p. 92.

‡ *Journ. Comp. Path.*, 1918, Vol. XXI., p. 168, Ref.

since been seen in Germany and other parts of Europe. It possibly occurs in Great Britain, but absolute proof is wanting. The fowl is most commonly attacked, and the disease does not show a great tendency to spread amongst other birds, these often escaping though exposed to infection. Experimentally, the disease can be transmitted with difficulty by inoculation and by ingestion to other poultry. Freese* failed to infect old and young ducks and old geese. The pigeon enjoys a high degree of immunity and the domesticated mammals are not susceptible. Freese has described outbreaks among geese in Germany, and has recorded the fact that sparrows may become infected by contact with fowls suffering from the disease. Birds become infected by the ingestion of fæces, which always contains the virus and which is the chief agent in the spread of the disease. The important discovery by Freese that sparrows may become infected indicates one method by which outbreaks may be originated. The period of incubation is 3 to 5 days in natural cases, and the disease often runs its course in 2 to 4 days or it may be longer.

The mortality is high and few cases recover. According to Leclainche† the virus does not live long in soil or water but is relatively insensitive to desiccation, dried blood remaining infective for 20 to 25 days. The virus is more easily destroyed by disinfectants, but is very resistant to glycerine. Maggiora and Valenti‡ found that blood hermetically sealed in pipettes and kept in a cool, dark place retained its virulence for at least 45 days. Exposed to air and diffuse sunlight the virus remained active for 15 days, and on a hot summer day virulence was lost in 40 hours. The virus in blood is destroyed by 5 minutes' exposure at 65° C.

Avian Diphtheria (*diphtheritic roup*) is a specific disease of birds characterised by the production of false membranes on the throat and nasal passages. Some have held that avian and human diphtheria are one and the same disease, and have cited instances in which it was alleged that birds had originated outbreaks of diphtheria in the human subject. In some instances examination of the evidence has shown no valid grounds for the assertion, and in other instances the evidence was at least doubtful. The disease has also been held to be a form of epithelioma contagiosum of birds (Hutyra and Marek).§ The truth of these assertions also seems to be very doubtful and, at the present time, it can be laid down

* *Journ. Comp. Path.*, 1918, Vol. XXI., p. 212, Trans.
† *Journ. Comp. Path.*, 1904, Vol. XVII., p. 83, Abs.
‡ *Journ. Comp. Path.*, 1918, Vol. XXI., p. 169, Ref.
§ Hutyra and Marek, *Spec. Path.*, Vol. I., p. 424, Trans.

as nearly certain that avian diphtheria is a distinct and definite morbid entity.

The cause is not known with certainty, though according to the researches of Bordet and Fally* it is an extremely small organism, which is always present in the false membranes and which produces hardly perceptible growths on special culture media. Others (Guerin, Nocard) considered the cause to be a pasteurella. The disease is conveyed by inoculation and by ingestion, but infection does not easily occur and long contact with virulent material is necessary. It usually lasts from 2 to 3 weeks; recovery is sometimes complete and occasionally relapses occur. Friedberger† places the mortality at 50 to 70 per cent. and much higher in young birds.

Epithelioma Contagiosum (*avian variola, fowl pox*).—A contagious disease of poultry characterised by the occurrence of wart-like eruptions on the unfeathered portions of the body and particularly on the comb, wattles and eyelids. Outbreaks occur among fowls, pigeons, turkeys, geese, &c. Marx and Sticker‡ showed in 1902 that the virus of the disease will pass through a bacterial filter. According to the later researches of Borrel, Burnet and others it seems to be rather uncertain whether the disease should be classed among those due to ultravisible viruses. According to Burnet§ the cause, which can be readily shown by inoculation to be present in the lesions, is at least as large as the organism of bovine pleuro-pneumonia and can be detected microscopically. At the same time it has frequently been found to pass through the more open-grained bacterial filters. Natural infection may occur either by contact or by ingestion of scales which drop off diseased birds. Experimentally the disease can be conveyed by inoculation or by feeding. Marx and Sticker‖ have shown that the virus is very resistant, thus material from the lesions was infective after being heated to 60° C for 3 hours. A crust containing the virus was infective after exposure for 2 months to desiccation and light and, at times, to direct sunlight. The virus was destroyed in half an hour by 2 per cent. carbolic acid, but not by 1 per cent. The nodules in glycerine are infective after 30 days. The disease apparently becomes adapted to one species of bird, the transmission from one species to another is not always easy. The period of incubation is 5 to 6 days. The disease is not usually fatal, the warty lesions

* *Ann. Inst. Past.*, Vol. XXIV., p. 563.

† Hutyra and Marek, *Spec. Path.*, Vol. I., p. 434.

‡ *Journ. Comp. Path.*, 1918, Vol. XXI., p. 171, Ref.

§ *Journ. Comp. Path.*, 1918, Vol. XXI., p. 173, Ref.

‖ *Journ. Comp. Path.*, 1918, Vol. XXI., p. 172, Ref.

generally shrivelling up in 3 to 4 weeks and dropping off. One attack confers immunity which may last for several months.

Fowl Typhoid was recognised in Germany by Pfeiler* who first described it in 1912. In an outbreak involving 87 fowls, of which 43 died or were killed when dying, Pfeiler isolated an organism belonging to the typhoid group. A second outbreak occurred in 1915 in which the same type of organism was found, and the disease was transmitted by means of cultures to fowls, pigeons and ducks. Ducks and geese, however, do not appear to become infected in natural outbreaks, whereas turkeys and guinea fowl do.

Preventive Measures.—Fowl cholera, fowl plague and fowl typhoid call for similar measures for eradication. Once these diseases are introduced they usually, of their own accord, cause the death of most of the birds, but it is advisable to cut short outbreaks by killing off the whole stock and by burning or deeply burying the carcases in lime. An exception may only be made in the case of very valuable birds which have not been exposed to infection. These must be isolated on fresh ground until it is quite certain they are free from disease. The place in which the birds have been kept must be thoroughly disinfected, limewashed and left vacant for a period before any others are introduced. Hen coops and such like are best burnt and new ones provided. If disease exists in the neighbourhood, any newly purchased stock should be quarantined for a period to ensure that no infection be introduced. The soil of the poultry yard should be turned up to a depth of 4 to 5 inches and mixed with fresh lime.

In view of the milder nature of the other diseases described, viz., avian diphtheria and epithelioma contagiosum, affected birds need not be destroyed, but the stock may be divided into two batches, viz. :—(1) those apparently healthy and (2) those affected. Any birds subsequently showing symptoms are moved to the affected group. One need only destroy birds which are especially badly affected. Disinfection must be practised and the usual measures designed to prevent spread of the disease to healthy poultry stocks must be put into operation.

GAPES.

Gapes of poultry is due to the presence of the nematode *Syngamus trachealis* in the trachea and bronchi. Fowls and turkeys and a large number of wild and game birds are attacked.

Young birds are more susceptible than old ones, and a high

* *Journ. Comp. Path.*, Vol. XXX., p. 263, Ref.

mortality sometimes occurs among young chicks and young turkeys.

The male and female parasites, of which the former is the smaller, are in more or less constant union, and when the pregnant female is coughed up on to the poultry runs the eggs are either scattered about the ground or the worms themselves are eaten by the chicks so that the eggs and embryos pass on the infection without the necessity of an intermediate host.

It has been pointed out that earthworms eat the eggs and are themselves in turn eaten by chicks, the worms acting as accidental hosts and not as necessary ones.* Illness and death of the infested birds is due to bronchitis, weakness and anæmia due to the constant irritation and loss of blood from the parasites sucking blood from the mucous membranes, and also from suffocation.

Preventive Measures.—Overcrowding should be avoided. Sick birds must be isolated, chicks should be kept on clean ground and the ground on which they are reared should be changed from year to year. Infected runs should be dressed with freshly-slaked lime, which should be well raked in. Hen coops, and feeding and drinking utensils must be thoroughly cleansed and disinfected.

Infected chicks will require suitable treatment, and those that die should be burnt.

BLADDER WORMS.

These are the larval forms of the adult tape-worms or cestodes. The three groups of importance to the veterinary hygienist are :—(1) *cysticercus;* (2) *cœnurus;* (3) *echinococcus.* The cysts or "bladders" are found in various parts of the bodies of their hosts according to the site for which each species has a predilection. Specific injury done to the host depends upon the peculiar location of the cysts, as will be shown later. Apart from immediate injurious effects, which the presence of the cysts causes, they depreciate or even render valueless the flesh of infected animals; furthermore, as they are the precursors of the adult tapeworms, their destruction is as important as that of the worms themselves.

Cysticercosis.—Each cyst contains but one head and can give rise to but one adult worm.

C. cellulosæ.—Of chief significance in the pig, though it has also been found in man, the dog and the cat. Pillers gives its most common sites in the pig as the shoulder, neck, tongue, intercostal and psoas muscles. In bad cases any muscles may be involved, though it is but rarely found in the internal organs.

* *Leaflet* No. 58, 1918, Board of Agriculture and Fisheries.

Infection is transmitted to the pig through ingesting the eggs of *T. solium* excreted in human fæces. It is not as yet clear how the larval forms reach their resting places.

"Measly" pork is unfit for food, as a high temperature is required to destroy the parasite which might therefore escape destruction under ordinary conditions of cooking. The ingestion by man of undercooked "measly" pork gives rise to *T. solium* in the intestines, and in this way the cycle is completed.

PREVENTIVE MEASURES.—These should be directed toward the hygienic disposal of human fæces. Pigs rooting in woods, undergrowth, or behind hedges and in similar places would become infected if people who defæcate in such places harbour the adult tapeworm. Protection is afforded to people by the proper inspection of meat and the efficient cooking of pork sausages. Greater opportunities are offered for contamination of the land with *tæniæ* in country districts than in towns owing to the more indiscriminate disposal of human fæces and to the more cursory inspection of meat.

C. bovis.—This is the larval form of *T. saginata* which is sometimes found in the intestines of man. The cysts are located chiefly in the masseter muscles; more rarely in other parts. Cases are seldom met with in this country, though fairly common in Germany and other parts of Europe.

PREVENTIVE MEASURES.—These are the same as for *C. cellulosæ,* and especial care should be taken that the drinking water of bovine animals is not contaminated with human fæcal matter.

C. tenuicollis.—This larval form of *T. marginata* is found chiefly in the peritoneal cavity and liver of the ox, sheep and pig. The adult worm is parasitic in the dog.

PREVENTIVE MEASURES.—Prevention is secured on the one hand by burying or otherwise effectually destroying all dead sheep or other animals, and on the other hand by administering vermifuges to farm dogs and destroying their excreta.

C. pisiformis.—These cysts are found in the peritoneal cavity and liver of rabbits and hares, being the larval forms of *T. serrata* which inhabits the intestine of the dog.

C. fasciolaris.—Is found in the liver of rats and mice, the adult form being the *C. crassicollis* of the cat. Pillers* found it in 10 per cent. of rats examined in stables where cats were kept.

Prevention can be effected, as before indicated, by destroying the carcases of the cyst carriers and by the administration of vermi-

* *System. Vet. Med.,* Wallis-Hoare, 1915, Vol. II., p. 1489.

fuges to animals harbouring the adult worms, followed by destruction of their excreta.

CŒNUROSIS.

The cœnurus cyst differs from the cysticercus in that the single cyst cavity contains several heads, each of which, if conditions are suitable, may develop into an adult worm. It follows that the ingestion of one complete cyst may give rise to many tapeworms.

C. cerebralis.—Of chief importance and most common in the sheep it is also found in the ox and goat, and has been recorded in the horse. It has a marked predilection for the cranial cavity, but Pillers says that it has also been found in the vertebral canal. The cysts located in the cranial cavity cause the well-known train of symptoms referred to as "sturdy" or "gid." The disease is of considerable economic importance and is especially prevalent in certain districts, others being comparatively free from it. A wet spring seems to favour its occurrence. The adult tapeworm is the *T. cœnurus* of the dog.

C. serialis.—This, the cystic stage of *T. serialis* of the dog, is extremely common in Great Britain, and especially in some seasons. The rabbit is chiefly affected, and in this animal it is found in the subcutaneous tissues and between the muscles.

ECHINOCOCCOSIS.

Echinococcus polymorphus (*E. veterinorum*) is found in the ox, sheep, horse, pig and man, but chiefly in cattle and pigs. The adult tapeworm, *T. echinococcus,* inhabits the intestine of the dog. Cysts may be found in almost any tissues of the host, but the liver is the commonest site. Preventive measures are as before indicated. Dogs should not be fed on "trimmings" unless it is certain that they are free from cysts.

TAPEWORMS.

Tapeworms infect all the domestic mammals and birds, with the exception of the pig. They are of least consequence in the horse and ox, and produce the greatest losses among lambs.

Monieza expansa.—This is the tapeworm which is occasionally the cause of great losses among lambs. It is also found in the ox and goat, but with them it is not of so much importance. Lambs

when badly affected fail to thrive, and in some seasons there is a very high death-rate. The intermediate host of this tapeworm is unknown.

Preventive Measures.—Prophylaxis should be directed towards freeing the lambs of the worms and the destruction of the latter. This is, however, by no means easily accomplished. A common recommendation is to graze the contaminated land with animals which are not susceptible. Though this is not always practicable, it should be carried out whenever possible. The conversion of pasturage into tillage is a good policy to adopt, but here again the suggestion is not always feasible. Avoiding overstocking, together with top dressing the land with salt, iron sulphate, or lime, will do much to lessen the evil.

Measures to be adopted against cestode infection of dogs and cats have been discussed when considering bladder worms.

Distomiasis or Fascioliasis.—The trematodes of importance to veterinary practitioners in this country are *Fasciola hepatica* (*Distomum hepaticum*) and *F. lanceolata* (the latter being less common) of the horse, ox, sheep and goat. They are found in the liver, stomach and intestines, in the pancreas and also in the lungs and blood vessels, but before all others in the liver, causing the disease known as "liver-rot." The life-cycle of *F. hepatica* is as follows:—The hermaphrodite flukes lay their eggs, of which one may produce as many as 40,000, in the bile ducts of their host. The eggs pass out with the fæces to the ground, and from these 3 to 6 weeks later there hatch out ciliated embryos which find their way, if possible, to water in search of molluscs belonging to the genus "Limnæus." If the embryo succeeds in attaching itself to a mollusc it penetrates its pulmonary cavity, where it develops into a *sporocyst*. If no mollusc becomes available the life-cycle is not completed and the embryo dies. The *sporocyst* may divide into two or more *sporocysts*, from each of which arise six to eight *rediæ*. The latter then migrate to the liver of the mollusc, where may be produced daughter *rediæ*. In the summer months each of these may a second time produce daughter *rediæ*. In the winter months, however, development usually passes to the next stage, which is that of the *cercaria*, about a score of which may be produced by each *rediæ*. The *cercaria* bores through the mollusc to the outside, and being provided with a tail it propels itself and becomes attached to a blade of grass, on which it becomes encysted. If ingested by a sheep it undergoes slight changes and passes to the bile ducts *via* the duodenum. Pillers gives the number of adults which may develop from a single fluke at from nine to twelve

million. It need hardly be stated that the number is actually much smaller than this.

Fluke disease has a very wide distribution and is the cause of considerable financial loss, not only from actual deaths but from depreciation in value of such as survive. It is a disease of low-lying, wet and undrained pastures, or such as are liable to floods, and is most prevalent following a wet season. The *cercariæ* are unable to live on dry ground. Sheep are to be seen showing obvious symptoms in the autumn, winter and spring. Well-fed sheep usually escape any serious infestation and weakly bad thrivers are the first to be affected. The disease is much more serious among sheep than among cattle. Sheep grazing on salt marshes do not become affected.

Preventive Measures should follow the same lines as for other worm diseases. Drainage of the land is of prime importance, and the application of a top dressing of salt or iron sulphate is recommended. Overstocking should be avoided and feeding should be liberal, and of supplemental food the oil seed by-products are especially recommended. If fluke-infested rabbits abound on the farm they should as far as possible be destroyed.

The provision of a clean water supply is a necessity, and Pillers recommends adding six drachms of salt to every gallon of water supplied for drinking. Rock salt distributed in racks throughout the grazing ground is advisable. Livers which contain parasites should be destroyed or, if fed to dogs, should be well-cooked, otherwise dogs may spread the disease through their fæces, which may contain living eggs.

THE ROUND WORMS. NEMATHELMINTHES.

Helminthiasis is responsible for enormous financial losses in this country. While the treatment of helminthiasis is always difficult, the prevention of its occurrence is infinitely more so owing to the obscurity in which these parasites live, and the complexity of such life-cycles as are known.

Helminthiasis of the respiratory organs, causing "verminous bronchitis and pneumonia" in young cattle, lambs and young pigs, may have a mortality as high as 50 per cent. for either species. Other animals are exceptionally attacked. The disease is most marked in April and May, but often prevails from March right on to the end of autumn. The period of incubation is not definitely known; Pillers puts it at about two months, but in pigs it is certainly less. The parasites most commonly associated with

"verminous bronchitis" in the different domesticated animals are as follows:—In calves, *Strongylus micrurus;* in lambs, *S. filaria* and *S. rufescens* (the latter first described in this country by M'Fadyean); in pigs, *S. paradoxus;* in horses *S. arnfeldi.* Infection is believed to occur usually by ingestion, the larval worms after reaching the stomach travelling to the lungs during rumination. In the lungs they arrive at sexual maturity and lay eggs, which are passed out on to the land during the paroxysms of coughing. According to Miessner the first signs of illness in cattle appear 6 to 10 weeks after they have picked up the worms, but the time is variable and is more or less dependent upon weather conditions.

Preventive Measures.—As before. Affected animals should be housed or at any rate segregated so that the worms or ova coughed up are not scattered over a wide area. If housed, the litter can be collected and destroyed. It is probable that the eggs and larvæ are very resistant to adverse conditions. Since humidity and warmth are favourable to the development of the worms, pastures should be drained and low-lying areas should be avoided if possible. Stagnant pools and ditches should be filled up and a supply of good pure water provided.

Helminthiasis of the Alimentary Canal. — Ascariasis due to *A. megalocephala* is not in the horse of great clinical importance, though cases have been recorded where large numbers of these parasites have, by bunching, occluded the lumen of the gut. It is known that ascarides produce a toxin which has been shown to be capable of producing nervous disturbances. Ascarides are also found in the intestines of calves (*A. vituli*), *sheep* (*A. ovis*), pig (*A. suilæ*), dog (*A. marginata*), and cat (*A. mystax*).

Oxyuriasis.—The Oxyuridæ are not considered to be of great clinical importance in the horse.

Strongylosis.—This very serious condition is caused by a variety of parasites, notably *Sclerostomum equinum* (*Strongylus armatus*), *Sclerostomum tetracanthum* (*Strongylus tetracanthus*), *Sclerostomum vulgare* and *Sclerostomum edentatum.*

Preventive Measures. — As with other intestinal parasitic diseases attempts should be made to keep infected dung off the pastures. Fresh, clean water for horses at grass is imperative, and animals should not be allowed to drink from dirty pools. Grazing fields on the outskirts of towns set apart for the running of horses at grass are often very badly infected, and it must be remembered that horses carry the various helminthœs in their intestines for years and so convey the disease to any pastures on

which they may graze. In many instances horse-rearing has to be abandoned on farms on account of the extent to which the ground is contaminated, and to the fact that the breeding stock often persistently carry the parasites and re-infect such pastures as have been rested and cleaned. "Horse-sick" ground should be grazed by cattle or sheep for two or three seasons and all horses kept from it. It is now known that ascaris infection can be spread through the agency of rats and mice, for Stewart has shown* that the larvæ of *A. lumbricoides* and *A. suilæ* may be hatched out from eggs in the alimentary tract of rats and mice, whence they travel to the lungs. Stewart found the larvæ in the trachea and bronchi and mouths of these rodents on the seventh day after they were fed on the mature eggs. It is therefore obvious that grain and fodder could easily become infected with the larvæ. In consequence the destruction of rats and mice is indicated.

PARASITIC GASTRITIS.

This is most frequently observed in calves and lambs and is of greatest importance in these species, the disease often appearing as an enzootic.

Strongulus convolutus (Ostertag) is the commonest cause of parasitic gastritis in cattle, though M'Fadyean† in this country encountered a much smaller worm to which he applied the name *Strongulus gracilis*. In sheep the causal parasites are *S. contortus, S. cervicornis,* and others.

The disease is especially severe in young animals, *e.g.,* in the case of cattle from 6 months to 2 years of age, the chief symptoms being diarrhœa, emaciation and anæmia. In acute outbreaks the mortality may be as high as 90 per cent., and the course of the disease may be only a few days, but is more often 2 to 4 weeks. In adult animals death may also occur, but the disease more often assumes a chronic condition lasting for months or years. Cases are usually seen in late autumn, winter and early spring, but may occur at any time of the year, and though most frequent in wet seasons, according to Penberthy, are not confined to these.

The life history of *S. contortus* has been worked out recently by Veglia‡ in South Africa. He found the eggs and larvæ to be capable of considerable resistance to destructive agencies, *e.g.,* desiccation, though sunlight is the chief devitalizing factor. It is only after protracted rainy weather that a large percentage of

* *Brit. Med. Journ.,* July, 1916, p. 5.
† *Journ. Comp. Path.,* Vol. IX., p. 314.
‡ *Journ. Comp. Path.,* 1906, Vol. XXIX., p. 265, Abs.

eggs mature, and this explains the heavy infestation of flocks after wet seasons. Mature larvæ stored on the ground are able to pass the winter without heavy mortality.

Preventive Measures consist of efficient anthelmintic treatment, good feeding, with an addition of salt to the ration, an abundant supply of pure water and avoidance of stagnant pools. It is advisable that the animals should be housed with the object of restricting pasture contamination. All litter should be burnt. The pastures should be sprinkled with lime or salt, or be ploughed up. Hay from such pastures should be fed to animals which are not susceptible, *e.g.*, horses.

FLIES.

Limitation of space does not permit of a detailed account of the numerous flies that are of importance to the veterinary hygienist in the British Isles. The reader is referred to the article by Noël Pillers in W. Hoare's *System of Veterinary Medicine*.

Biting and sucking flies worry all animals, horses and cattle especially, not only by their actual contact, but by their mere presence. The stable fly, *Stomoxys calcitrans,* which is a blood-sucking fly, is common in stables and byres from the spring until the autumn. It is very annoying to all stabled animals, and especially to the sick.

It has been shown that the presence of a number of flies in a cow byre reduces the milk yield of the cows. The common house fly, *Musca domestica,* is beyond any doubt responsible for the dissemination of disease, and every effort should be made to destroy it in all stages of its existence.

The danger of the common house fly to man and also to animals is due to the fact that it is born in filth and spends its brief but active life paying a constant series of calls from filth to food and food to filth. As the filth may, and often does, contain pathogenic bacteria, and as the fly is so constructed that when it alights on filth much of the latter adheres to it, it is not difficult to realise its potential danger.

The metamorphosis of the common house fly takes from a week to a fortnight, or much longer in cold weather, the stages of development being, egg to larvæ or maggot, maggot to pupa, and pupa to adult. Warmth is necessary for the development of the larva from the egg, hence fermenting material, such as manure or decaying animal or vegetable matter, is always chosen by the stable fly and the house fly for oviposition.

Manure pits are the most favoured breeding places and horse manure is preferred to cow manure. Cow manure contains too much moisture and the surface becomes caked over, both conditions being adverse to the life of the larvæ. Cow manure, if it contains much straw, may be used as a breeding site. Any rubbish lying about a farm or elsewhere affords a suitable breeding place. Any decomposing food material or excreta, that is food material that can be easily ingested by the adult fly and also serve as nutriment for the larvæ when they hatch out from the eggs, attracts flies both for immediate nourishment and as suitable spots for the deposition of their ova. Human and animal fæces afford suitable food, so also do milk and other foodstuffs found in houses.

Preventive Measures. — Protective measures against flies should be directed toward (1) reduction in the number of breeding places, or making such unsuitable; (2) destruction of the adult flies; (3) destruction of eggs and larvæ; (4) protection of animals from flies; (5) protection of human food, especially milk, from flies. General cleanliness and tidiness about animal buildings will do much to reduce the number of flies by removing dirt and rubbish. The most productive anti-fly measure is the destruction of eggs and larvæ in manure pits. Horse manure appears to be the outstanding breeding place for flies, and this fact may be made good use of. According to Roubaud* the manure must be fresh, not older than 24 hours, and oviposition usually takes place in the stable before the manure is put in the pit or heap. When the larvæ are hatched they are driven to the surface by the heat of the underlying manure.

According to Lelean† larvæ cannot tolerate a temperature of 100° F. and are rapidly killed at any temperature above 114°·8 F. In a closely packed heap of fresh stable manure the temperature may range from 136° F. to 169° F. four inches below the surface, which is fatal to both eggs and larvæ. Roubaud draws attention to the fact that the heat arising from the fermentation in a manure heap may be used as a means of destroying the larvæ that it contains.

When a manure heap is turned over the larvæ which come in contact with the hot parts in the interior are killed at once.

A complete stirring up of the manure on the day after the deposition, and repeated on the two following days, causes a disappearance, Roubaud says, of 90 per cent. of the larvæ.

Instead of placing new manure on the surface of the heap it should be buried in the hot parts by covering all its surfaces

* *Vet. Journ.*, 1918, Vol. LXXIV., p. 74.

† *Sanitation in War*, 1919.

with a layer of hot manure eight inches in depth. The manure pit, if properly treated, affords a ready means of destroying countless numbers of fly larvæ with but little effort. The addition of chemicals to manure with the idea of destroying the eggs and larvæ is contraindicated, as Roubaud points out that the fermentation of the manure is delayed, with the result that the period of infestation may be prolonged.

In addition to the destruction of eggs and larvæ, efforts should be made to destroy the adult flies.

Various methods have been recommended for this purpose, including the following:—The manure pit may be covered with leafy branches which have been sprayed with a poison bait composed of arsenite of soda, 6½ ozs.; sugar, 4 lbs.; and water 4 gallons. The young flies as they are hatched out settle on the leaves and feed on the poison. Flies may be destroyed in buildings such as stables and cow byres by fumigation with sulphur when the animals are out. Three per cent. of formalin in sweetened milk placed about a room in shallow vessels, such as soup plates or saucers, is calculated to destroy a number of the pests; a piece of bread should be placed in the centre of the dish for the flies to alight on and from which they can suck up the poisoned liquid. If the strength of formalin is greater than 3 per cent. the flies will not go near it. Fly papers and traps are all useful. The following prescription for making "Tanglefoot" is taken from Lelean's *Sanitation in War*: Heat together 5 parts of castor oil and 8 parts of powdered resin (both by weight) until the resin is completely dissolved; the mixture should not be brought to the boil, but should be applied while hot, or heated before application (as thinly as possible), to the surfaces to be coated. Tanglefoot may be spread on *glazed* paper, strands of wire, hoop iron, &c., which should then be hung in suitable places and be removed when necessary.

Many sprays and washes have been tried on horses and cattle to ward off flies. As the result of experiments Cory recommends spraying milch cows with a 3 per cent. solution of pine-tar creosote in caustic soda solution. Two-thirds of a pound of soda is dissolved in water for every gallon of creosote to be emulsified. The emulsion is effective for one day only, but affords some protection for three or even four days.*

WARBLE FLIES.

The Warble flies belong to the genus *Hypoderma*, of the family

* *Journ. Econom. Entom.*, 1917, Vol. X., p. 111, through *Vet. Rev.*, 1917, Vol. I., p. 457.

Oestridæ. They are true flies, but like the rest of the *Ostridæ* are unable to feed, as their mouth parts are rudimentary. The three species of importance in this country are *H. bovis, H. lineata* and *H. silenus,* and of the three *H. bovis* is the most common. *H. diana* attacks deer in Great Britain. *H. silenus* attacks horses. *H. bovis* is on the wing from July to September in this country and *H. lineata* usually appears a month earlier. The life-cycle is very complex, and all stages of it are not yet known. Hadwen* gives it as follows :—The eggs which are laid on the skin, take about a week to hatch and the issuing larvæ bore through into the subcutis. A skin lesion results due to bacterial invasion and partly to anaphylactic reactions; *H. lineata* produces the more severe lesions. The larvæ next appear in the œsophagus, but how they get there is not known; they pass down the submucosa of the œsophagus and then wander to the neural canal, passing from the gullet under the pleura either up the crura of the diaphragm or up the posterior border of the ribs and enter the canal by the posterior foramen. From there they descend the canal under the dura mater, to emerge again through the foramen and ultimately reach the back where they mature and form the swellings known as warbles.

Larvæ are never found in muscular tissue, but confine their wanderings to connective tissue. Hadwen gives the average pupal period for *H. bovis* as thirty-two and a half days and a little less for *H. lineata*. Mote† found that *H. bovis* formed 83·5 per cent. of the total warble flies collected in the State of Ohio, and Macdougall‡ records the examination of 190 maggots by Steven taken from the hides of beasts slaughtered in Scotland, and of this number 148 proved to be *H. bovis* larvæ and the remainder *H. lineata.*

When the mature larva emerges from the skin, it drops to the ground and there pupates for about six weeks. The complete life-cycle occupies nearly a year.

The flies terrify cattle and cause them to stampede, and accidents sometimes result. The continual unrest which is sometimes caused by these flies is known to diminish the production of milk, and the damage done to hides is enormous.

Preventive Measures.—If a careful examination were to be made periodically of cattle known to be harbouring warbles and these destroyed, the warble fly would, in time, be eradicated.

It is useless to press out mature grubs and let them drop to

* *Journ. Amer. Vet. Med. Assoc.,* 1917, LI., p. 541, through *Vet. Rev.,* 1917, I., p. 389.

† *Ohio Journ. Sci.,* XVII., p. 169, through *Vet. Rev.,* 1917, I., p. 390.

‡ *Trans. High. Agric. Soc.,* 1915, XXVII., p. 230.

the ground, this is working for the pests and not against them. Warbles persist owing to carelessness and indifference. If shelter sheds are provided in the fields cattle will take cover in them when pursued by the flies which will not enter a shed. The injection of one drop of tincture of iodine into the tumour kills larvæ. Lucet recommends the simpler method of stabbing the grub with a heated lancet or knitting needle. Glaser found that birch oil, which is very cheap, applied to the hides of cattle before leaving the sheds for the pastures effectively kept the flies away.*

Lard, cart grease, vaseline, or other fatty or oleaginous substance, applied fairly thickly over the nodules, blocks up the "breathing hole" in the skin and suffocates the larva.

THE SHEEP NOSTRIL FLY.

The sheep nostril fly, *Ostrus ovis,* belongs to the same family as the warble flies, the *Oestridæ,* and like them has only rudimentary mouth parts and is unable to feed in the adult state, consequently its life, as a fly, is short. The female lays either eggs, or larvæ already hatched, about the nostrils of sheep in the months of July and August. If the weather is unpropitious the female does not fly abroad, but waits for a fine day; it is under these conditions that the eggs hatch out within her body and larvæ are then extruded in the place of eggs. The larvæ crawl up the nostrils and attach themselves to the mucous membrane in the nostrils or in the air sinuses. There they remain feeding for about ten months and drop out from March to May. When nearly ready to leave the air passages for their pupation period they crawl down the nostrils thereby irritating its sensitive lining membrane and causing the sheep to sneeze, which act hastens their expulsion. They pupate just beneath the soil. Though the actual mortality from these maggots is negligible, sheep badly infested lose flesh and depreciate in value.

Preventive Measures.—Prevention may be effected by smearing the noses of the sheep with tarry dressings that repel flies seeking to alight. Pillers suggests the use of salt-boxes so designed that the sheep smear their noses with oil and tar when they use the box.† Another effectual method which is in common practice is to draw a single furrow across every 40 or 50 yards of the field in which the sheep are herded in the hot season. During the heat

* Second Report of the International Commission for the Preservation, Cure and Disinfection of Hides and Skins.

† *System of Vet. Med.,* Wallis-Hoare, 1915, Vol. II., p. 1431.

of the day, when the adult female flies are abroad for egg-laying purposes, the sheep stand with their noses in the furrow and access to their nostrils is denied the intruder, which is loth to enter a virtual "pit" in the soil.

In the case of very valuable sheep it is not uncommon to have to trephine the nose or sinuses and remove maggots with forceps.

SHEEP BLOW-FLIES.

Sheep maggots are the larvæ of the "green bottle fly," *Lucilia seriatica or L. cæsar,* or less commonly of the "blue bottle," *Caliphora.* The female lays as many as 500 eggs in clusters of 50 on the wool of the sheep; heavy, greasy wool and sheep with soiled quarters being especially attractive to them.

Sheep badly infested with keds, with shoulders and loins denuded of wool by rubbing or biting, are frequently "struck" on the bare parts. Lambs, sick sheep, and those lame, as from foot-rot, are more often attacked than are healthy vigorous sheep. The life-cycle is completed in about 28 days, the period from egg deposition to fully grown maggots taking 14 days. A number of generations is hatched during one season. Several species of blow-flies attack domestic animals and man, laying their eggs about the anus, &c. Wounds especially attract them, and horses with greasy heels and cankered hoofs and those with the prepuce coated with inspissated smegma are very liable to become infected with species of blow-fly maggots. Sheep dogs with foul hindquarters and hair matted with excreta are specially liable to be "struck."

From May to August is the blow-fly season in this country, July and August being about the worst months. The maggots literally live upon their host, and sheep if much neglected eventually die; such cases are, however, uncommon, but depreciation in value owing to the set-back badly "struck" sheep suffer is certain. It is generally considered that a "struck" sheep is a magnet to other blow-flies. Immediately before a fall of rain on a sultry, vapid day, or just prior to a summer thunderstorm, when the atmosphere is very oppressive, the flies are particularly annoying, and sheep may be seen huddled together with their heads down, and frequently stamping, in an endeavour to protect themselves by congregation.

Preventive Measures.—Some means of shelter from the mid-day sun should be provided, and even morning and evening feeding may be necessary, the middle part of the day being spent in a park or wood where abundant overhead foliage affords a cool shade. Sheep folded in the middle of an open field for the whole of the

day suffer most. Prevention should aim at the destruction of the flies and keeping the sheep as clean as possible so that they are less attractive to the flies. Destruction of the flies may be effected by destroying the larvæ or maggots before they drop off the sheep to pupate. Burying or otherwise destroying the carcases of sheep and all other animals, including rabbits and birds, will do much to keep down this pest by denying them suitable egg-depositing places, but a very good method is to provide " traps " in the form of carrion, such as dead rabbits, &c., on which the flies may lay their eggs and which are collected and destroyed. Sheep should be inspected daily during the blow-fly season. Maggots must be removed and destroyed, not merely scraped off and allowed to drop on to the ground. Soiled fleece should be cut away from the anal region, and sheep dogs should be kept clean. Suitable antiseptic ointments help to ward off further attacks, and wounds on all animals require appropriate surgical treatment. Brown* suggests the destruction of flies by the liberation of poison gas, the sheep being removed meanwhile to higher ground. Brown points out that cross-bred sheep and those with light dry wool are not so often attacked by the fly as are merino sheep, in which the wool is dense and greasy. A thorough washing of sheep at the beginning of summer removes the dirt and grease from the wool which is so attractive to the fly, and it is well known that dipping lessens the risk of " strike," the cleaner the dip leaves the sheep the greater is the protection. Sulphur dips are especially useful for this purpose. In some localities the sheep are collected in the early morning while the fleeces are still wet with dew; dry powdered arsenic dip is dusted into the fleece along the back and around the hindquarters. It is said that this affords protection for about a week or ten days, unless rain washes it off.

SHEEP KEDS.

The sheep ked, *Melophagus ovinus,* one of the *Hippoboscidæ,* sometimes miscalled a " tick," is a true six-legged fly, although without wings. Its life-cycle is completed on one host, the sheep. The adult ked clings to the wool of the sheep with its clawed feet and lays, not eggs, but fully developed larvæ. The outer covering of the newly laid larva soon hardens to form a pupa case, within which the ked matures. The female is said to produce five or more young successively.† Keds may move from shorn sheep on to

* *Queensland Agric. Journ.,* 1917, Vol. VII., p. 85, through *Vet. Rev.,* 1917, Vol. I., p. 456.

† *Leaflet,* No. 74, *Dep. Agric. Tech. Inst., Ireland.*

unclipped lambs for the greater protection the fleece of the latter affords. They subsist mainly on blood sucked from their host, but may derive some nourishment from the grease of the wool.

Destruction of keds is assured by suitable dipping of the sheep with dips that contain arsenic. *Melophagus ovinus* cannot live for any length of time away from a host. Georgina Sweet and Seddon kept the parasites under a variety of conditions to test their viability. They found that a moderately cool and uniform temperature is the most favourable condition for its existence away from a host and without food, especially if it be dry. Thus keds were found to live on bare soil on a lawn for two and three-quarter days; on moist grass in a cellar for six and three-quarter days; on moist grass on a lawn for five and three-quarter days; on bare soil in a cellar eleven days; and on dead leaves on soil in a cellar for eleven and three-quarter days. If extremes of temperature be present, then moisture is necessary for the life of the ked, dryness soon proving fatal.*

HORSE BOT FLIES.

The horse bot flies, *Gastrophilus equi* (*G. intestinalis*) and *G. Hæmoidalis,* of the family *Oestridæ,* are on the wing during the month of August.

The female of the former lays her eggs chiefly on the hairs over the metatarsus and metacarpus of the horse, and that of the latter chiefly on the lips. It is generally considered that the larvæ on hatching out set up an irritation that causes the horse to lick the region affected and thus the larvæ reach the stomach where they attach themselves almost exclusively to the cardiac region.

Roubaud† concludes from his researches that the eggs do not hatch spontaneously, but that the ripe eggs wait, perhaps for weeks, to liberate their larvæ only on mechanical contact with the lips, tongue or teeth of the horse. The primary larvæ, according to Roubaud, freed by contact with the mucous membrane of the lips and gums, immediately bury themselves under the epithelium. They migrate and grow under the epithelium and, when they have attained a certain size, become free and are swallowed. It is known that *Gastrophilus* larvæ, unlike those of *Hypoderma,* cannot penetrate the skin. The bot larvæ remain in the stomach of their host for about ten months and then pass out with the fæces to pupate in the soil, from which they emerge as adult flies in about six weeks.

* *Vet. Journ.,* 1917, LXXIII.
† *C. R. Acad. Sci.,* CLXIV., p. 453.

The larvæ may become attached to the mucous membrane of the pharynx, and Canon has recorded the presence of *G. pecorum* in the pharynx of 15 horses that came from South Africa.* Bots may set up pharyngitis and sometimes, though rarely, gastritis. The stomach seems capable of carrying enormous numbers of these parasites without any obvious harm or malaise accruing, but perforation of the gastric wall sometimes results with a fatal ending.

Prevention of infestation may be at least partially secured by smearing the legs of horses during the fly season with an oily dressing containing tar or creosote, or with common paraffin oil. General Sir Frederick Smith has recommended a weekly singeing of the egg area of horses at grass.

LICE.

Lice are readily divided into two distinct classes (*a*) the Blood-Sucking Lice, which include the *Pediculinæ* of man and *Hæmatopinidæ* of animals, and (*b*) the Scurf or Feather-Eating Lice which include the *Trichodectidæ* and *Gryopidæ* of animals and the *Menopenidæ* of birds.

Lice of both classes are found on all domestic animals. Those of the first class are the more injurious, as not only do they cause, as a rule, greater irritation and quite an appreciable loss of blood, but they are in many cases disease carriers—*e.g.*, in the human subject the great scourges of war, typhus and trench fever, are carried by *Pediculidæ*. A few of the second class also carry pathogenic parasites—*e.g.*, the Trichodect of the dog is known to carry the larval stage of *Dipylidium caninum*.

While the presence of lice is, in general, indicative of neglect and dirt, it must be remembered that some animals are peculiarly attractive to these vermin. Old age and an impoverished condition of the body undoubtedly predispose to lice infestation.

The life-cycle of the louse is comparatively a simple one. The female lays about a hundred eggs and each one is attached singly by a glutenous material to the base of a hair. The eggs or " nits " hatch into young lice in from fourteen days to a month, and these after feeding and moulting become adult.

Warburtan† found that with human lice the eggs hatched in from 8 days to 5 weeks; the larval stage lasted 11 days; a male lived 3 weeks and a female 4 weeks. He considers that under

* *Vet. Record,* XXX., p. 107.

† Quoted by Macdougall, *Trans. High Agric. Soc.*, 1916, XXVIII., p. 108.

the most favourable conditions the life-cycle from egg to egg would be about 24 days.

The Hæmatopine louse is far more common on the horse than is the Trichodect, thus Hall found 22 cases were *H. assini* and but 2 *Trichodectes* out of 24.

PREVENTIVE MEASURES.—Maintaining the body in a clean condition, by grooming in the case of horses, washing and grooming for dogs, grooming for cows and dipping for sheep, is the chief deterrent to the spread of lice. Clean bedding and a sufficiency of good, nourishing food are also important factors.

Horses brought up from grass are frequently found infested with lice.

If lice appear on a horse in a stud it is wise to treat the entire stud with suspicion as the vermin are readily carried on grooming tools. Clipping and singeing are the initial steps to take toward the eradication of these disgusting pests, and a suitable parasiticide dressing should follow. Whatever dressing, dip, or wash is used it is important to remember that many eggs escape destruction and therefore the treatment should be repeated weekly for 3 or 4 weeks.

For cattle or sheep any approved sheep dip is suitable, the former may be washed the latter dipped. The application of sheep dips to the bodies of horses is to be done with great caution, especially if they contain arsenic. Pigs may be dressed with any non-blistering oily dressing and cottagers frequently rub lice-infested pigs with lard.

Various dressings are advocated for the destruction of lice and their eggs. The following is recommended for cattle:—Arsenious acid, 1 oz.; soft soap, 2 ozs.; carbonate of soda, 1½ ozs.; water, 2 pints. Boil the whole together and dilute to 5 gallons.

Mayr* recommends the use of Ikaphthisol, a white powder consisting of magnesium carbonate, bolus alba, talc, crude cresol, sapo medicatus, and oxytoluol or cresyl alcohol. From 5 to 7 ounces of this powder is to be dusted on to a horse; this is said to kill the lice in a few minutes. Mangin's method of destroying lice and eggs is as follows†:—Eau de Javel, 400 c.c.; potash soft soap, 200 grammes; water, 10 litres. This quantity is sufficient for one horse. The soap is dissolved in hot water and the Eau de Javel (hypochlorite of sodium) is added immediately before washing begins. Mangin claims that eggs as well as lice are destroyed. The solution should be left to dry on the animal.

**Berliner tierarztl. Wochenscher,* XXXII., p. 279, through *Vet. Rev.,* 1917, I., p. 85.

† *Rec. Med. Vet.,* XCII., through *Vet. Rev.,* 1917, I., p. 396.

This method has received much criticism, adverse as well as favourable. The author has used it extensively for horses and dogs and usually with good results. Dogs should be soaked for 20 minutes or so in the bath at body temperature and then left to shake themselves dry, care being taken, of course, that they are not exposed to cold. In using this wash it is well to remember that the success of the treatment depends chiefly upon the strength of the bleaching powder (so-called "chloride of lime") of which the sodium hypochlorite is made. This substance very soon decomposes unless kept in stoppered bottles, so that the chloride of lime as purchased in the shops in cardboard cartons instead of containing 30 per cent. or more of available chlorine may yield less than half this amount. For this reason the author invariably uses twice the quantity of bleaching powder that is prescribed for making sodium hypochlorite.

Other dressings commonly used on horses and cattle are :—a solution of perchloride of mercury, 1 to 1000; a 3 per cent. solution of a coal tar disinfectant, or a decoction of stavesacre, four ounces to each gallon of water.

The treatment of grooming tools, harness, stall partitions and the like should be similar to that advocated for mange-infected articles.

Infestation by lice causes, in horses, a dermatitis simulating mange, and it must not be forgotten that the two may, and frequently do, co-exist.

When dogs are infested with lice they should be subjected to a weekly soak in Mangin's solution for at least three successive weeks; the sleeping baskets, kennels and rugs must be thoroughly cleansed and disinfected, otherwise the treatment of the animal itself will be of little avail.

The N.C.I. powder, recommended for the use of men, may perhaps be suitable for dogs. It is composed of naphthaline, 96 parts; creosote, 2 parts; and iodoform, 2 parts, this is to be dusted on to the clothing or hair as the case may be. A caution is given that if used too liberally the powder causes an irritation of the skin.

Fowls are often found to suffer greatly from lice, of which they harbour numerous species. The ill effects are perhaps more intense than those caused by fleas. Badly-infested birds are unthrifty, and egg-laying is interfered with. Young chickens fail to grow, and their general unthrifty condition renders them more susceptible to disease, and they may even die from debility. Prevention is secured by attending to the cleanliness of the poultry houses and nests. A periodic and thorough cleansing with subsequent white-

washing of the houses and the destruction of dirty nest boxes will do much to keep away these troublesome vermin. For fowls infested with lice the following remedies are suggested.* The provision of dust baths, which should be kept in a dry, sunny place to ensure that the dust is kept dry. The application to adult birds of flowers of sulphur or pyrethium powder. Dressing adult birds with an ointment of sulphur and lard. Young chickens may have their heads and necks rubbed with a little lard. The nests should be kept clean and frequently dusted with lime or insect powder. A lime and sand bath, in the proportion of one of the former to three of the latter, helps to keep fowls free from lice.

FLEAS.

The fleas to which the veterinary practitioner has his attention called are the human flea, *Pulex irritans,* which also attacks dogs and cats, the dog flea, *Ctenocephalus canis,* the cat flea, *C. felis* and the fowl flea, *Ceratophyllus gallinæ.*

Fleas act as carriers of infective diseases, *e.g.,* plague, and it is known that the dog flea acts as the host for the cystic form of *Dipylidium caninum* of the dog and cat. The facility, not to say eagerness, with which they sometimes migrate from the dog or cat to people makes them peculiarly objectionable. The fowl flea causes a considerable amount of trouble among fowls and chicks, and their presence in any numbers is an indication of dirt and neglect. If young chickens are badly infested they do not grow, and may even die from loss of blood and want of rest. A flea-infested nest is not attractive to hens.

Preventive Measures in the case of fowls call for attention to ordinary hygienic requirements, the provision of properly constructed fowl-houses, which should be well lit and ventilated. The nest boxes must be of the removable type and be capable of easy cleansing, which should be done frequently and regularly.

A periodic cleansing and limewashing of the houses and fittings with a pint of kerosene added to each gallon of wash will keep down the number of fleas. Sulphur fumigation is also a valuable method of destroying these pests. Fleas can be kept from dogs and cats by cleanliness and the application of suitable flea powders. Sleeping accommodation must be regularly attended to. It is to be remembered that eradication of tapeworms in dogs demands the destruction of the egg-carrying flea.

* *Leaflet,* No. 30, D. A. T. I. I.

TICKS.

Ticks belong to the Natural Order Acarina and to the family Ixodoidæ. Of the many species and sub-species which are known throughout the world, two are of importance in this country, *Ixodes ricinus* and *Hæmaphysalis punctata.*

Ticks are of great economic importance as they act as carriers of various diseases in the Tropics, and in the British Isles are solely responsible for the spread of bovine redwater and apparently play an important part in the transmission of louping-ill of sheep. Their life-cycle* is of interest to the hygienist, and that of *I. ricinus,* which is a three-host parasite, is as follows :—The female lays her eggs, of which there may be as many as 2000, in the grass in groups, and having completed her egg-laying she dies. From the eggs develop in from 2 to 5 months small hexapod larvæ, or " seed ticks," which attach themselves to the first available host. The seed ticks may have to wait for months before a suitable host passes within reach. Having gorged themselves on the host, the seed ticks drop to the ground and moult to octopod nymphs, and still further moulting when on the ground brings them to adult ticks. The female becomes impregnated when on the body of a host and when fully gorged drops off and begins to lay her eggs. The male tick is not a blood sucker. The life-cycle is not the same for all species of ticks, some requiring three hosts while others are satisfied with and complete their metamorphosis on one.

During any stage of their life-cycle ticks may live for many months away from a host, for six to ten months or even longer.

Ixodes is parasitic on cattle, sheep, horse, dog, goat and cat, and sometimes on man; in the summer time seed ticks often fasten themselves on to children when they sit on the grass. Both *I. ricinus* and *H. punctata* transmit redwater in Great Britain.

Preventive Measures.—It is easy to suggest measures for the eradication of ticks, but very difficult to put them into effective operation. In countries where ticks play an important part in transmitting disease drastic measures are called for in order to eradicate them. Large tracts of land known to harbour ticks are fenced off from cattle, and by this means the ticks are starved out or are cleaned of disease as they are unable to suck blood containing bovine piroplasms. Burning and clearing the land destroys a large number of ticks and removes the cover that is necessary for them. Converting pasturage into tillage ground is an effective

* See also under *Redwater*.

measure, but unfortunately much tick-infested land is quite unsuitable for the plough. Periodic dipping of cattle and sheep, preferably with arsenical dips, or spraying with paraffin emulsion are recommended. Sheep may be grazed on land infested with redwater-carrying ticks; this serves to collect the ticks, which may then be destroyed by dipping.

PARASITIC MANGE.

General Statement.—The mange mites are epidermal parasites which, though the various genera differ in some important points in their mode of life on their hosts, all possess certain similar features that are of considerable importance to the hygienist. Those that call for attention are :—*Sarcoptes, Notœdres, Cnemidocoptes, Psoroptes,* and *Symbiotes* or *Chorioptes.*

The mites are, in general, oviparous, and it takes about four weeks for the life-cycle to be completed. Roughly, the sequence is as follows :—a hexapod larva develops from the fertilised egg in from 4 to 7 days, which by moulting becomes in 3 or 4 days an octopod but sexless nymph. By a further 3 or 4 days the nymph has become adult. Oviposition takes place about a week after copulation. Gerlach* estimated that one generation, about one and a half million progeny, should develop in the course of three months. It is said that eggs fail to develop away from the warmth and moisture of the body.

Resistance of Mange Mites.—According to Hertwig† mange mites die in a few days if placed exposed in a room, probably on account of the lack of moisture. If kept moist on the skin they may live for three weeks or more, but in a dry atmosphere they die in fourteen days. Brandl and Gmeimer conclude that the optimum temperature for mange mites is from 59° to 86° F., and that at 97° F. they become dry and shrivel. In warm water, according to these investigators, the mites live for twelve to fourteen days, and in cold water for nine to twelve days. Testing the action of certain chemicals on the mites, the above workers found that chloroform, bisulphide of carbon, and glacial acetic acid immediately kill them. *Liquor cresoli saponis* and carbolic acid in 2 per cent. watery solution kill in from two to three minutes. A 1 per cent bichloride solution takes half an hour and a 20 per cent. decoction of tobacco leaves did not destroy the mites in three hours.

* *Epizootics and their Control during the War,* Miessner, 1915, English Trans. by Liebold, 1917, *Vet. Med. Series,* No. 15, Chicago.

† *Epizootics and their Control.*

Arsenious acid in from a $\frac{1}{2}$ to a $1\frac{1}{2}$ per cent. solution did not kill mites exposed to its action for twenty hours. It is frequently stated, chiefly by laymen, that mange parasites can live in an empty stable for months, and that if a stall that has held a mangy horse be vacated for as long as six months it is still infective. Mange parasites have been credited with the power to lie dormant in crevices in the stall divisions for an almost indefinite period, and to this many have attributed the periodic outbreaks that undoubtedly do occur in some stables. It is more probable that the horses have never been properly cured and that a few parasites remain more or less quiescent on their skin, to resume activity when the conditions of the skin and other predisposing factors are favourable to them. Nevertheless it would be the height of folly to rely upon natural disinfection to rid a stable of the nuisance; vigorous disinfection should be employed. The viability of the mange parasite away from its host is a question having great importance from a legal point of view.

Period of Incubation.—Not much is known as to the time that elapses between infection and the symptoms that the mites have obtained a hold on their host. Schumann* experimented on two horses with the sarcoptic mange mite and concluded that with long-haired horses the incubation period lasted seventeen days and twenty-four days where the hair was shorter. Long winter hair, perhaps, affords more favourable conditions for the parasites.

The Effects of Mange Infection.—A pruritus of varying intensity accompanies mange infection. This is due to juices of an irritating nature secreted by the mites and not to the mechanical actions of biting, sucking or crawling. The intensity of the prurigo is most marked with psoroptes and least with chorioptes, sarcoptes being between the two. The irritation is worse in the stable than in the open air owing to the warmth increasing the activity of the mites; for the same reason the application of a rug on the horse causes him to bite and tear at the body with increased vigour. If neglected, the parasites spread practically over the whole animal and the irritation gets so severe and constant that the unfortunate animal gets no rest, consequently it fails to thrive, becomes cachectic and eventually dies. Psoroptic mange may, however, remain confined to the tail for long periods. Emaciation is not a cause but a result of mange infestation. Starvation, bad stable management and mange often go together, but mange may be found on occasion where the management of the stable is good and the food excellent.

Sheep scab (see page 365) causes loss of condition of the sheep,

* *Deutsche tierarztl. Wochenschr,* XXIV., p. 194, through *Vet. Rev.,* I., p. 86.

depreciation in the value of the fleeces and great dislocation of the sheep trade, as well as a considerable pecuniary burden that has to be borne by the general public. In dairy byres mange is very common in some districts and is the cause of loss of milk and general unthrivitiness of the affected cows. A byre full of mangy milch cows is not a pleasing sight when there is a possibility of having to drink the milk.

Differences in the Mode of Life of the Mange Parasites.—Psoroptes live on the surface of the skin but suck their nourishment from it. Sarcoptes possess biting jaws and the ovigerous females burrow. The Chorioptes or Symbiotes are scale-eating mites and neither puncture nor burrow into the epidermis. While mange parasites may be found on any part of the body, the majority of sarcopt cases are primarily localised in one of three places, withers, throat or inside of thighs. Symbiotes are primarily found on the extremities, especially on the hind legs, but if neglected they extend over a large body area.

Though diagnostic methods have no place in such a book as this, it may nevertheless be urged that appropriate measures be taken first to be certain that mange *does* exist, and second, if present to determine its nature. Mange cannot be diagnosed by scratching an animal with the end of a stick, and "evidence" so obtained should not be accepted by any authority.

Incidence.—The first Mange Order came into force in 1912, and the returns for that year show that in Great Britain there were 2873 outbreaks with 6608 animals attacked. In 1913 the number of animals attacked was reduced to 4467. During a part of 1913 and a part of 1914 the Order was suspended. In 1916 there were 2147 outbreaks affecting 4689 animals; in 1917, 2614 outbreaks with 4873 animals. In 1918 the disease increased to such an extent that the official returns show 4483 outbreaks involving 8422 animals.

Ireland is, as indicated by the returns, comparatively free from mange. In 1912 there were 69 outbreaks with 121 animals attacked, and in 1916, 74 outbreaks with 106 animals affected.

Mange is more common in towns than in the country, though the scarcity of horses during the war led many farmers to purchase low-priced animals from town sales in order to carry them through hard working periods. Such purchases sometimes resulted in the infection of farm studs where previously the disease was unknown.

With regard to *seasonal incidence,* the official returns show that mange is at its height during December, January and February. March shows the beginning of the decline, which continues through-

out the summer and autumn to December, when there invariably appears a sudden and pronounced increase. A. Gofton compiled a table from the official returns which shows very clearly the rise and fall of this disease, and he says that this is identical with that which he observed in the army under active service conditions.* No satisfactory explanation of this seasonal fluctuation has as yet been offered.

SARCOPTIC MANGE.

Varieties of *Sarcoptes scabei* affect man, horse, ox, sheep, dog, pig, goat, camel and other animals. Each species of animal has its own variety, but the parasite may occasionally pass from one species of host to another, although under such conditions, as a rule, the infection is only of limited duration. Thus bovine sarcoptic mange frequently affects milkers, causing "dairyman's itch"—a condition well known to veterinary surgeons. Equine sarcoptic mange occasionally passes to grooms and hospital attendants. Canine sarcoptic mange is frequently met with, at least by veterinary practitioners, located on people; the author has seen a man, his wife and child all badly affected with sarcoptic mange contracted from a Yorkshire terrier.

In *horses* sarcoptic mange is often considered the most difficult to cure, owing to the burrowing habits of the female, but the psoroptic variety is frequently equally refractory. It is doubtful if a period less than two months could be allowed with safety for treatment and isolation.

Sarcoptic Mange of the Ox.—From time to time cases of sarcoptic mange are reported in the veterinary journals as if this parasite was a rare one on bovines. As a matter of fact it is very common, far too common, among the dairy cows of cities. Pillers also has found it of common occurrence in the winter time. This disease is not scheduled, though many think that it should be. With this we concur, as the presence of mange in dairy cows is an indication of neglect, and clean milk cannot be obtained from mangy cattle. Unlike the disease in horses bovine sarcoptic mange is confined almost exclusively to the root of the tail and the posterior region of the udder, rarely it spreads forward. A peculiarity of bovine sarcoptic mange is the readiness with which the parasites are obtained from a scraping; in a very small area the author has often found an enormous number of parasites in all stages of

* Paper read before Conference of Veterinary Inspectors, Newcastle-on-Tyne, 11th August, 1919; *Vet. Record,* 11th October, 1919.

development. It yields to treatment much more readily than does the same disease in equines. It is the most common form of mange in cows. Infection spreads very rapidly from one cow to another on account of the close contact with which the animals lie in their stalls.

Sarcoptic Mange of the Dog.—In marked contrast with the bovine disease the canine parasite is very difficult to find, thus it is probably often mistaken for eczema, an opinion with which Pillers concurs. It is interesting to note that many so-called cases of eczema are treated successfully with parasiticides.

Sarcoptic Mange of the Pig is also common but does not call for special mention.

Notœdric Mange of the Cat may be mentioned here, as it is often confused with sarcoptic mange; unlike that disease on the dog, it can be diagnosed with comparative ease.

PSOROPTIC MANGE.

The *Psoroptes communis* is found on horses, cattle, sheep, goats and rabbits. It does not pass to man, at least not to obtain lodgment there. Psoroptic mange of the horse and sheep, the latter being known as "sheep scab," are the only two of hygienic importance in this country. Pillers suggests that these parasites may live for a time on a horse without causing any clinical symptoms; few will disagree with this opinion, and it is important to keep the possibility in mind in connection with outbreaks, the orgin of which may be difficult to trace.

Psoroptic otacariasis is of common occurrence in the rabbit and goat, and Henry* has stated that psoroptes are frequently found in the ears of horses and sheep and also, but less frequently, in the ears of donkeys and mules.

He concludes that otacariasis is an important factor in the preservation and propagation of psoroptic mange. Later, Craig† made a point of examining the ears of sheep for acari, and found psoroptes in the ears of a few sheep that had come from a flock affected with sheep-scab. He therefore urges that, in dipping sheep, care should be taken that the dip reaches the inner side of the ear.

EQUINE SYMBIOTIC OR CHORIOPTIC MANGE.

Symbiotic mange affects all the domestic animals, with the exception of the pig. It is a very slow-spreading disease, and new

* *Rec. Med. Vet.*, XCIII., Nos. 3-4, p. 41, 1917; through *Vet. Rev.*, 1917, I., 260.

† *Vet. Record*, XXIX., p. 503.

colonies, if found, are usually in close proximity to the original site. This particular mange is only of importance with horses, and is the cause of the itchy legs so commonly seen among heavy draught animals. The itching is sometimes productive of serious injury from the constant stamping and kicking it causes. Usually confined to the lower extremities, and especially the hind legs, it sometimes spreads upwards and along the body, and cases occur, with greater frequency than is generally realised, where the initial lesion is in the mane, tail or part of the body. The author has seen a farm horse, neglected at grass for several months, with two-thirds of his body infested. The disease is said to be more prevalent in winter than in summer.

Psoroptic and sarcoptic mange of the horse, mule and ass and psoroptic mange of sheep are the only forms of the disease that are scheduled as notifiable.

Methods of Transmission.—Mange of the horse, ass and mule is spread by direct contact between diseased and non-affected animals and by numerous indirect media, among the most important of which are the harness, clothing, bedding, grooming tools, stalls and their fittings, and the door-posts against which animals are liable to rub in passing to and from the stable. The under face of mangers and hay-racks are especially liable to hold the parasites owing to these being favourite places for horses to rub their necks and manes on. The shafts of carts must also be considered as possible receivers of the parasites, though probably retaining them only for a short period. The shoeing forge must always be regarded as a centre from which the disease is disseminated, and probably the shoeing-smith's apron is the most common indirect medium for transmitting symbiotic mange. Mange is commonly introduced into a clean stable by the purchase of an affected animal, and its presence may not be detected until several of the horses have become obviously itchy. A mangy horse put up at a livery stable, if only for an hour or so, may be the cause of a lot of trouble, especially if it is groomed.

Preventive Measures.—Despite all precautionary measures, mange sometimes finds its way into a stable but, as a rule, its appearance among a clean stud of horses is due to carelessness. Most commonly its introduction is due to the purchase of a slightly infected animal, therefore care should be taken to examine intended purchases for any suspicious symptoms of the disease. Itchiness of the skin may of course be due to other causes than mange, such as lice, dirt, or to the presence of certain of the forage acari. If no mange acari are found and there is no other obvious

cause for the skin irritability, the animal should be treated as a suspect and isolated accordingly. While positive evidence is positive, negative evidence is not necessarily conclusive. So far as is possible strange horses should not be allowed to put up even for a short time in the stable.

If compelled to stable one's horse in a common livery stable in a town it is a wise precaution to carry a halter if it is at all possible to do so. Under no circumstances should the grooming tools in common use at a livery stable be used, as these are very seldom cleaned, and are passed from one horse to another without discrimination. If it can be avoided, harness should not be loaned; inquiry into the source of origin of an outbreak of mange has often shown that the owner of the infected animals lent a set of harness to a friend who wished to try an intended purchase in harness and had not a set himself that would fit. Once mange has been found in a stud, the greatest care requires to be taken to prevent its spread from one animal to another. If the stable management is good and the horses are carefully attended to, mange should be detected very soon after its introduction, but it is astonishingly true that in a great many instances the disease has obtained a good hold before the stable foreman thinks fit to take any action.

As soon as the presence of either sarcoptic or psoroptic mange is suspected, the police constable of the district must be notified, the animal or animals isolated, and every precaution taken to prevent its spread. Suspected animals may not be taken outside the premises without the written consent of the veterinary inspector. All the harness and grooming kit must be carefully disinfected (see pages 218 and 225), the bedding must be kept separate from that of non-infected animals, and the animals themselves should, if conditions permit, be isolated in a stable apart from the rest of the stud. If there is only one stable, then the infected should be segregated and kept as far apart from the rest as possible. The stalls from time to time must be well cleaned and disinfected, and receive a final disinfection when the horses are considered cured. If all the stalls in the stable are occupied, there may be considerable difficulty in getting them cleaned and disinfected so that there are clean stalls in which to put the horses as the disease becomes progressively less infective. It is obviously of little use to attempt to cure a horse of mange while leaving him in a stall that harbours the parasites. Where there is more than one horse affected a man should be set aside to give his whole time to them, thus not only is the disease overcome with greater celerity, but there is less chance of the clean animals becoming infected.

If there is only one horse affected among a stud, the owner would be well advised to have it removed to a veterinary establishment where it will be out of harm and probably be more speedily cured. Sanction for removal must, of course, be obtained from the veterinary inspector of the local authority. If it is not the ordinary stable practice to provide each horseman with his own set of grooming tools this should be done immediately the disease is suspected, and all such kit must be kept clean and frequently washed in an alkali solution to remove the grease and dirt.

In some stables it is the practice to spread the least soiled bedding out in the open in the morning and then to re-apportion it among the stalls when dry. If mange is present this must on no account be allowed, even among the clean horses. The harness of all the animals, whether diseased, incontacts or clean, should be periodically cleaned, dried in the air and dressed with some harness composition. The use of rugs, bandages and other clothing should be restricted as far as possible and, of course, under no circumstance should any harness be transferred from one animal to another. Pillers draws attention to an important and often overlooked fact, namely, that on the death of a horse the parasites leave it as soon as the body begins to cool and set out on a search for another host.

In conclusion it is well to remember that it is quite impossible to say with certainty whether an animal is free from mange mites. It is therefore well to extend the period of after-treatment isolation as long as can conveniently be done.

Sarcoptic Mange of the Cow is introduced into a byre by the purchase of an infected animal. It spreads with rapidity from one cow to another, being carried on grooming tools, udder cloths, the hands, caps and clothes of milkers and, in paired stalls, from the contact of one cow with her neighbour. The parasites and their eggs drop or are brushed off the hindquarters, fall into the bedding, and thus get passed up and down the byre. Attendants frequently put their hands on the part of the cow most commonly affected, the posterior lumbar region and base of the tail, and so carry the parasites from one animal to another. Sufficient evidence that the disease is spread by the attendants is found on their arms, few milkers escaping from " dairyman's itch " when the cows are mangy.

It is by no means easy for the dairyman to prevent the entrance of a mangy cow into his byre as it may, at the time of purchase, be so slightly affected as to escape notice and, unfortunately, the disease is not scheduled—which undoubtedly it should be—so that the buyer in the open market has no redress or protection. When

sarcoptic mange has been detected by the dairyman he can do much to prevent its further spread. Needless to say, mangy cows should be immediately dressed with suitable dressings, care being taken to avoid mercurial or other poisonous chemicals or substances likely to taint the milk. Affected cows should be stalled together with as many empty stalls as possible between them and clean animals. There must be no interlapping of the bedding, and no common use of udder cloths or grooming tools.

Diseased cows should be milked and attended to the last of the herd, and it were wise if the milkers used separate overalls and caps when milking such animals. It is however very difficult to induce dairymen, at least most city dairymen, to take vigorous steps to eradicate the trouble.

There is little doubt that the warm moist atmosphere so often found in city byres favours the rapid multiplication of the parasites.

DEMODECTIC MANGE.

Demodectic or Follicular Mange is commonly associated with a marked dermatitis with pustule formation and the presence in the nodules of the *Demodex*. The demodex is to be found on all domestic animals and on man, but is generally recognised to have pathological interest and to produce or to be associated with disturbing lesions chiefly in the dog and pig. A follicular dermatitis has, however, been recorded in the goat, ox and other animals. The parasite has been found repeatedly on the horse, and the author on more than one occasion has found it associated with skin depilation.

Canine follicular mange is generally considered to be but rarely and with difficulty transmissible by contact between diseased and healthy animals, and how the disease originates or what are its exciting or predisposing causes are as yet unknown. It has been suggested, and there is reason to believe, that the demodex may be a common and usually innocuous resident in the dog's skin. A. E. Mettam isolated a staphylococcus from an advanced case and from it prepared a vaccine which had definite curative action, which gives support to the opinion of others that the demodex is but the exciting factor in the disease.

Preventive Measures.—Though infection from one dog to another by contact, either directly or indirectly, is not regarded as common, it would be unwise to regard follicular mange in any animal as non-contagious, and precautions should therefore be taken accordingly. Infected animals should be isolated, and in the case

of dogs, the kennels, baskets, rugs, &c., should be thoroughly disinfected.

PSOROPTIC MANGE OF SHEEP. SHEEP SCAB.

Sheep-scab, due to the presence on the skin of *Psoroptes communis v. ovis,* is the cause of considerable financial loss to sheep owners. Badly infected sheep fail to thrive owing to the continuous pruritis and want of rest. There is considerable damage done to the fleece and, as is to be expected, a general depreciation in value of the flocks. There is additional loss resulting from the time and labour expended in dipping and carrying out the regulations enforced to combat this preventable disease.

The regions primarily affected are the back, withers and rump, but, if neglected, the mites spread until eventually the whole body becomes affected. The disease is more prevalent in cold than in warm weather, and removal of the fleece may have an inhibiting action on the activity of the mites. It is well known that psoroptes can, and frequently do, remain in a quiescent state for several months, and isolated clumps of acari may be detected in and about the ears and at the root of the tail in sheep which are not suspected of being scab-infected. Such sheep may act as carriers and spreaders of the disease without the flockmaster having any suspicion of the fact. In connection with this most important point the Chief Veterinary Officer of the Board of Agriculture says* that the acari of sheep scab can remain on a sheep for long periods without producing noticeable symptoms of the disease. Herein lies one of the chief difficulties of eradicating the disease. The same authority points out that a sheep but slightly affected, or one insufficiently dipped, may remain healthy in appearance for 2 or 3 months and then become visibly affected. It is further stated that such recurrences usually take place in the autumn or winter; thus scab may appear without any apparent reason on a supposedly clean farm. It is, furthermore, not possible by any practicable means to detect scab on animals but mildly affected or on such as act as carriers. Other conditions which cause dermatitis and pruritis may also mask a dual infection.

It is said that acari have been found to live away from sheep for a month to six weeks at the longest, but most of them die sooner than this. Eggs have been observed to hatch out two or even four weeks after removal from the sheep, but the majority hatch in a few days. The duration of the whole life-cycle is given as from 12 to 16 days, 23 days being the longest by calculation (Stockman).

* Cd, 7423.

The incidence of Sheep-Scab in the United Kingdom for the three years 1912-1914 is shown in this table, which has been compiled from the official returns.

Year	1912	1913	1914	Average	Outbreaks per 100,000 animals.
ENGLAND.					
Census	14,504,489	13,736,438	13,651,965	13,964,297	
Outbreaks	134	105	122	120	0·8
SCOTLAND.					
Census	7,004,367	6,801,126	7,025,820	6,943,771	
Outbreaks	57	46	48	50	0·7
WALES.					
Census	3,548,876	3,393,848	3,607,729	3,516,814	
Outbreaks	110	84	56	83	2·3
IRELAND.					
Census	3,828,829	3,620,724	3,600,581	3,683,378	
Outbreaks	386	565	474	475	13·1

Methods of Transmission.—Sheep-scab is transmitted within a flock by direct contact of one animal with another and indirectly from contact with contaminated rubbing-posts, tree trunks, hurdles, gates, fences and pens. Fleece that has been pulled out by an animal, or that has dropped out, holds the mites for a certain period, and if it should become attached to posts and the like the next sheep that rubs against the post may become infected. The disease is spread from one country, or part of a country, to another through the purchase of diseased animals, and it has been pointed out how difficult it is to detect sheep-scab in other but distinctly affected animals. It is known that scab is passed from Ireland and Scotland into England, and that the passage of a consignment of sheep from one country to another is not always a clear cut transaction, the animals may change hands and become mixed *en route.* Common grazing on moors and hills where a number of flocks run together is a notorious means of spreading the disease.

PREVENTIVE MEASURES. — Sheep-scab is a notifiable disease, being scheduled under the Diseases Animals Act. Prevention of the spread from an infected flock to other flocks is effected by compulsory notification of the existence, or suspected existence, of the disease and consequent isolation of the infected animals until such time as the disease is eradicated. Portal inspection of sheep shipped from one country to another, as from Ireland to Great Britain,

undoubtedly checks the flow of scab into this country, but, as has been pointed out, portal inspection cannot be expected to detect all cases of scab infection. It therefore serves as a check but not as an absolute preventive.

Sheep-scab having appeared among a flock dipping is imperative. One dip is useless, and it is more than doubtful if a double dipping, the second taking place 10 days after the first, can be regarded as a certain safeguard against re-infection. A flock of sheep dipped in a perfunctory manner is a serious danger to the sheep breeding industry as there is always the danger of infective animals remaining which may start the disease afresh in the flock, or, what is worse, be the means of starting the trouble in a fresh area.

Concurrently with the dipping of infected animals attention should be paid to the various indirect media of contagion. Gate posts, hurdles, rubbing-posts and other things likely to have come in contact with the sheep must be cleared of wool and treated with a disinfectant. A suitable disinfectant for this purpose is limewash containing 5 per cent. of carbolic acid. The whitewash serves a useful purpose by indicating what parts have been treated with the carbolic and what have been missed.

Sheep Dips.—There are more than 500 sheep dips that have been approved by the Board of Agriculture. Every dip used under the Sheep-Scab Order (see page 385) for the compulsory dipping of sheep, whether they are diseased or not, must be approved by the Board as suitable. A large number of the proprietary dips are convenient to mix and handle as well as being efficient. A dip is more efficacious on shorn sheep than on those with long fleece. Dipping is done with greater safety a fortnight or so after shearing, as this allows the sheep to get accustomed to the loss of their covering and gives time for any cuts and abrasions to heal; this is not unimportant, as many of the dips contain poisons that might be absorbed through the broken skin. Dipping should not be done on a rainy day as the dip would then be washed off too soon; neither should sheep be exposed to the dip when they are thirsty or very hot; if rounded up from any distance in hot weather time should be allowed them to cool off. Dipping tanks or baths are made of various styles and sizes to suit local requirements. The two chief types are the small hand bath and the swim bath. The former is used where small lots of sheep are to be dipped, and the latter when the flocks are large. Though small hand baths are economical to build they are extravagant with labour, and the work is hard on the men when the dipping is being done, and there

is more likelihood of animals being imperfectly dipped than with the larger swim bath. The hand bath is usually made of wood or cement concrete and its common dimensions are 4 feet long, 4 feet deep, and about 1 foot 9 inches wide. With such a bath the sheep are lifted in and turned over on their backs; they should be held in the bath for two minutes, or if less time is allowed then the dip must be well rubbed into the fleece. The head must be immersed at least twice, and it is important to see that the ears are filled with the dip. A swim bath is so constructed that the sheep are not handled but are driven down into the bath, through which they must swim, the time occupied being two minutes. The head must be immersed in the dip. Such a bath is easier on the men, saves time and is better for the sheep, as they are less liable to be hurt, and, furthermore, the dipping is more certain. The dimensions of such a bath would be 30 feet long at the top and 20 feet at the bottom, 5 feet deep and about 1 foot 9 inches wide. The sheep walk down into the tank and having swum through walk up and out. A bath having dimensions intermediate between the two described is often used. Whatever type is used it is of fundamental importance that the animals remain in long enough for the dip to thoroughly permeate the fleece. Having gone through the bath the sheep must be allowed to drip on a place so that the superfluous dip runs back into the tank; such drippings must not be allowed to run off on to pasture, as many dips are poisonous and fatal poisoning may occur. When the dip becomes reduced in volume it must be made up with dip of the requisite strength and not with water.

As well as being an efficient parasiticide a suitable dip must possess other qualifications. The permeability or " soakability " of the dip is of great importance, especially when the fleece is greasy. It must not harm the sheep nor damage the fleece. Wool staplers object to carbolic and pitch oil preparations. For dips recommended by the Ministry of Agriculture see the Sheep-Scab Order of 1920.

Rène's dip is as follows:—Dissolve arsenious acid, 2 lbs., sulphate of zinc, 10 lbs. and aloes, 1 lb. in 20 gallons of water.

Rène recommends that the sheep be well scrubbed while in the dip, and that they remain in it from one to five minutes. The sheep should have been previously shorn and, before being dipped, should be well soaped and all crusts on the skin thoroughly softened.*

A. Seymour-Jones suggests that a " sulphur " dip might be made by immersing the sheep in a bath of sodium hyposulphite of 5 to

* *Progrès Agricole,* 1917, XXXI., p. 200, through *Vet. Rev.,* I., p. 394.

10 per cent. strength for a minute or two, and then running them through a bath of an organic acid solution of ½ per cent. strength, which would decompose the sulphur upon the skin and wool; the evolution of sulphurous acid gas, he says, would act as an excellent disinfectant. "Such a dip would be perfectly safe, even in inexperienced hands, and the materials so cheap and readily available as to be within the reach of all."*

The improper use of dips, or the use of improper dips, not infrequently does serious damage to the pelt and even to the sheep, even necessitating their slaughter. Seymour-Jones (loc. cit.) writing on the damage to pelts, say it is due entirely to the use of non-approved dips by stock-raisers in their nervous anxiety to eradicate the disease regardless of consequences to the pelt and pain and suffering to the sheep. He points out that the arsenical dips, being strongly alkaline, have a corrosive action, and the carbolic dips, being strongly acid, have a peculiar tanning effect which may blister. According to this writer, shepherds, when they discover scab, try to eradicate the evil by pouring concentrated dip over the affected part, which runs down the body causing a wound wherever it touches.

Apart altogether from the treatment of scab, the dipping of sheep is very beneficial to them; it is a preventive against blow-fly and, owing to its cleansing action, improves their health and vitality. A most successful sheep farmer in the Border district has said to the writer that he considers dipping the best "meat" he gives his sheep, and but for the labour entailed would dip them more frequently than he does.

So long as dipping is regarded merely as a police measure it will not be done effectually. Education is more potent than regulation.

Stockman gives some valuable information in connection with the eradication of scab.† The importance of the double-dipping for the complete destruction of the parasites is emphasised. It is pointed out that scab appears in flocks which have been dipped once in the year, or twice with a long interval. The interval between dipping and the appearance of scab may be from one to four months or even longer. "With reference to the effect of a single dipping, I am not prepared to say that one dipping will not cure scab in the first few days after infection, nor can it be denied that a single dipping temporarily checks the spread of scab in an infected flock, but it has only a limited effect upon the dissemination of the disease from flock to flock through sales." He says, further, that

* *The Sheep and its Skin,* by A. Seymour-Jones, 1913.

† *Journ. Comp. Path.,* 1910, XXIII., p. 303.

there is evidence to show that a badly infected flock may not be cured by two dippings at short intervals. " There is this important difference, however, that there is satisfactory evidence that scab can be eradicated from infected flocks by carrying out two annual dippings with a short interval between each."

This same authority says that scab follows a regular course throughout the year. It begins to increase in October, is at its maximum in December and January, and then gradually declines. In June, July, August and September—especially July and August—the outbreaks are negligible.

FOOT-ROT OF SHEEP.

Foot-rot is of two kinds, non-contagious and contagious. The *non-contagious* form is often mistaken for the contagious variety. It is due to injury to the feet or the coronet, with splitting of the hoof and other injuries that may allow dirt to gain entrance to the underlying parts. Conditions which favour foot-sore, or non-contagious foot-rot, are marshy ground, with resulting overgrowth of the hoof from want of attrition. Overgrown and neglected hoofs are liable to break away and thus leave the sensitive laminæ exposed to dirt, gravel, &c. Any injury to the feet will cause foot-sore, such as travelling for long distances on hard roads to sheep sales. A large number of sheep in a flock may be affected with foot-sore in the same way that a number may be affected with contagious foot-rot.

Contagious Foot-Rot.—This is to a large extent a preventable disease and one that causes a great deal of trouble to the flock-master, considerable pain and inconvenience to the affected animals, with consequent unthrifty condition, and financial loss to the stock-owner. Owing to its contagious nature an early diagnosis is very desirable in order to differentiate between it and the foregoing. The Ministry of Agriculture draws the attention of shepherds to an important distinguishing feature between the two forms.* With non-contagious foot-sore the hoof is primarily affected; with true contagious foot-rot the disease starts originally in the soft tissues of the feet, and, later, the horny structure becomes affected. Contagious foot-rot may be present on either dry or wet pastures, and spreads rapidly from one sheep to another.

Preventive Measures.—Careful attention to the sheep, watching for lameness, and examining and trimming damaged feet, with strict isolation of any diseased or suspected sheep, will go far toward

* *Leaflet,* No. 154.

preventing the spread of this disease should it be found in a flock. New purchases should not be put on clean pastures until they have been carefully examined, and should be kept in isolation for a month. All fresh arrivals should be put through an anti-foot-rot bath as a precaution. The shepherd, after examining suspected feet, or after dressing diseased feet, should wash his hands in disinfectant and also disinfect his paring knife before going on to examine non-infected animals. Pastures known to be infected should, if possible, be left vacant for the greater part of the winter. The treatment of contagious foot-rot is best effected by passing the animals through an antiseptic footbath, and, as this same measure is a preventive one, its consideration here is not out of place.

The Board (now the Ministry) of Agriculture and Fisheries initiated the bath treatment of foot-rot, and the following recommendations are taken from their Leaflet.* The bath may be of wood or concrete, it should be 16 feet long and 8 ins. wide with sides sloping outwards, the ends of the bath should be 3 ins. in depth. The side fences should be about 3 feet 6 ins. high and 22 ins. wide at the top. The solution through which the sheep are to walk which has given good results is 1 lb. copper sulphate in 1 gallon of water, or half this strength if prevention only is aimed at. The copper sulphate must be of good quality and should not be in very large lumps. Badly affected sheep should have their feet dressed before being put through the bath. A day when the grass and soil are dry should be chosen. Sheep should be slowly walked through the bath, and especial care in this respect is necessary with ewes with lamb at foot so that the udder does not get splashed. As copper sulphate or any other effective foot-rot solution is poisonous, the bath should be covered over when not in actual use.

Various other substances are used instead of copper sulphate, of which the following may be cited:—Three ounces of arsenic with three ounces of washing soda boiled in two gallons of water; one part of commercial sulphuric acid to ten parts of water; sheep dips are also used. A not uncommon method of dealing with foot-rot is to spread freshly slaked lime in a gateway through which the sheep are slowly walked. Of all the methods in use the copper bath is probably the most effective. Dressing each affected sheep separately and allowing them three hours' rest in a well strawed yard afterwards is a good method. All necrotic and cheesy or broken horn is pared from the foot, and a dressing composed of alum, 1 oz., copper sulphate, 1 oz., and Stockholm tar, 3 oz., is

* *Leaflet,* No. 154.

applied to the sole and in between each claw. If the coronet is affected, the wall should be pared away and the dressing applied to the area attacked. Periodic paring of all sheep's feet once every 5 or 6 weeks in wet weather, or when the sheep are on wet or marshy land, will do much to reduce the incidence of the non-contagious form. Thorns in the heels of sheep and suppuration of the inter-digital scent gland, both of which cause lameness very similar to that of foot-rot (*i.e.*, feeding in a kneeling position, inclination to lie much, a three-legged gait, &c.), require to be differentiated from the true foot-rot.

SECTION VII.

SANITARY LAW.

List of Abbreviations used in the following Text

B. of A. . .	Board of Agriculture and Fisheries (now the Ministry of Agriculture and Fisheries).
D.A.A. . .	Diseases of Animals Acts.
F.A.Q.S. . .	Foreign Animals Quarantine Station.
I.B.A. . .	Inspector of the Board (Ministry) of Agriculture and Fisheries.
I.L.A. . .	Inspector of the Local Authority.
L.A. . . .	Local Authority.
L.G.B. . .	Local Government Board.
M.O.H. . .	Medical Officer of Health.
P.C. . . .	Police Constable.
S.I. . . .	Sanitary Inspector.
V.I. . . .	Veterinary Inspector.
V.I.B.A. . .	Veterinary Inspector of the Board (Ministry) of Agriculture and Fisheries.
V.I.L.A. . .	Veterinary Inspector of the Local Authority.
V.S. . . .	Veterinary Surgeon.

LAWS AND REGULATIONS.

In the following pages are given accounts of the more important of the laws and regulations with which the work of the veterinary practitioner or veterinary inspector is connected. It must be clearly understood that in no case is there given an exact rendering of an Act, Order or Regulation. What are thought to be the leading features have been abstracted, in some cases more fully than in others, mainly for the convenience of students preparing for examinations.

THE DISEASES OF ANIMALS ACT, 1894, 1896, 1903, 1909 AND 1910.

The Diseases of Animals Act, 1894, consolidates and amends the previous Acts of 1878 to 1893. Later Acts are the Act of 1896 which amends certain portions of the 1894 Act relative to the landing of foreign animals, the Act of 1903 concerning Sheep-Scab, the 1909 Act which gives authority for the payment of fees to veterinary surgeons for the notification of scheduled diseases, and the 1910 Act which deals with the exportation of unfit horses. In addition to these Diseases of Animals Acts there are certain other Acts such as the Dogs Act, the Poultry Act, the Protection of Animals Act and others. There are also many Orders made by the Board (Ministry) of Agriculture.

The Diseases of Animals Acts, &c., are administered by or under the supervision of the Ministry of Agriculture and Fisheries, which has great powers conferred upon it for the purpose of controlling animal diseases. For Ireland the powers conferred by these Acts are vested in the Department of Agriculture and Technical Instruction, which acts as the central authority for that country.

In the Act of 1894 certain diseases are scheduled as infectious diseases, and by the Act the Ministry has power to add to this list such other diseases as it may think advisable. At the present time the following are listed :—Anthrax,

Cattle Plague (Rinderpest), Foot-and-Mouth Disease, Glanders or Farcy, Epizootic Lymphangitis, Parasitic Mange of Horses, Asses and Mules (certain forms), Contagious Pleuro-Pneumonia of Cattle, Rabies, Sheep-Pox, Sheep-Scab, Swine Fever, and (at present suspended) Bovine Tuberculosis (certain forms).

The primary objects of the Ministry, so far as animal disease is concerned, is to prevent the entrance into this country of these scheduled diseases, to keep under control such as are here epizootic or enzootic and to work for their ultimate eradication. For these purposes the Acts are formulated for the compulsory notification of these diseases; for the immediate isolation or segregation of the diseased or suspected animals; to provide for the diagnosis of suspected disease by specially trained persons; for the slaughter of diseased or incontact animals where this may be necessary, and for the payment of compensation; for the apprehension and punishment of offenders against the Orders issued by the Ministry; for the systematic inspection of markets, sales, fairs and exhibitions, &c., and for the seizure therein of any "diseased" or incontact animals where this may be necessary; for regulating the transit of animals under all conditions, both for safeguarding the country from disease and also for the humane treatment of animals when in transit; for controlling the import of animals and things which may introduce disease, and for the inspection at the ports of disembarkation of living animals and for their slaughter while isolated.

The Local Authorities are required to execute and enforce the Acts and Orders.

In England and Wales the L.As. are (1) for Boroughs where the population exceeds 10,000, the Borough Council; and (2) for the residue of each administrative county, the County Council. For the City of London the L.A. is the Common Council which also acts as the L.A. for the County of London, where the Acts relate to Foreign Animals. For Scotland the L.As. are (1) the Magistrates and Town Councils of each burgh which contains a population of more than 7000; and (2) the County Council for each county and for residual burghs. In Ireland the whole of the powers which are conferred upon the Ministry are vested in the Department of Agriculture and Technical Instruction (Ireland).

Under Article 35 of the 1894 Act every L.A. is bound to appoint as many inspectors and "other officers" as the L.A. may think necessary, and must appoint at least one Veterinary Inspector and as many more as the Ministry may direct. The appointment of the inspectors of the L.A. is subject to the approval of the Ministry, but such inspectors, including veterinary inspectors, are responsible to the L.A., which is in turn responsible to the Ministry for the efficient working of the Acts and Orders. Local Authorities appoint certain of their police officers to act as inspectors.

Though the L.As. are required to enforce all the Acts and Orders pertaining to the scheduled diseases, the diagnosis and control of some of them rests entirely with the Ministry, with some partly with the Ministry and partly with the L.As., while for others the responsibility is wholly on the L.As., except that all the Acts and Orders must be executed to the satisfaction of the Central Authority, and that the L.As. or their officers must keep the Central Authority informed by forwarding reports of the existence, or suspected existence, of the diseases.

The diseases for the diagnosis and control of which the Ministry takes the responsibility are:—Contagious Pleuro-Pneumonia of Cattle, Cattle Plague (Rinderpest), Epizootic Lymphangitis, Swine Fever, Sheep-Pox and Rabies. When the existence of any one of these diseases is suspected the P.C. of the district must at once notify the Ministry (telegraphic address, Agrifi., Westrand., London) by telegraph as well as reporting to his L.A. Notwithstanding that the Ministry requires telegraphic notification of the supposed existence of these diseases, the L.A. must also obtain the professional opinion of its V.I., except in the case of Swine Fever.

In the case of Anthrax no telegraphic report is made to the Ministry. The L.A., through its V.I., may give a negative diagnosis or a tentative positive one, the latter, however, is subsequently confirmed or refuted by the Ministry.

The Local Authorities, through their V.Is., take the responsibility for the diagnosis of Glanders or Farcy, Parasitic Mange of Horses, Asses and Mules, Sheep-Scab and Bovine Tuberculosis.

GENERAL REGULATIONS THAT APPLY TO SCHEDULED DISEASES.

The following Regulations have a general application to all Scheduled Diseases :—

Notification of Disease or Suspected Disease.—This must always be made by the owner of the animal, or the occupier or person in charge, and by the V.S. in attendance, to the I.L.A. or P.C. of the district. Notice must be given without undue delay.

Presumption of Knowledge of Disease.—A person required to give notice if charged with failure to carry out his obligation shall be presumed to have known of the existence of the disease, unless and until he shows, to the satisfaction of the Court, that he had not knowledge thereof and could not with reasonable diligence have obtained that knowledge.

Separation of Diseased Animals.—Every person having a diseased animal shall, as far as practicable, keep it separate from animals not so diseased.

Facilities and Assistance to be given for Inspection, Cleansing and Disinfection.—Persons in charge of diseased animals are required to give every facility for the execution of the above, and must not obstruct or in any way hinder inspectors or other officers in doing their duty.

Prohibition of Exposure of Diseased Animals.—It is unlawful to expose a diseased or suspected animal in a market, sale-yard, fair, or other public or private place where such animals are commonly exposed for sale; to place an affected animal in a lair or other place adjacent to or connected with a market, sale-yard, &c., or where such animals are commonly exposed for sale; to send a diseased animal on a railway, or on any canal, inland navigation or coasting vessel; or to allow one on a highway or thoroughfare, or on any common or uninclosed land or in any insufficiently fenced field; or to graze one on the sides of a highway; or to stray on a highway or thoroughfare or on the sides thereof, &c.

Digging up Carcases.—No person may dig up the carcase of an "animal" that has been buried, without permission from the B. of A.

Veterinary Inquiry by Local Authority.—A L.A. on receiving information of the existence, or supposed existence, of disease must cause an inquiry to be made into the correctness of the report, with the assistance and advice of a veterinary inspector or veterinary surgeon. An exception to this among the Scheduled Diseases is Swine Fever.

ANIMALS (NOTIFICATION OF DISEASE) ORDER, 1919.

Application of Order.—The diseases to which this Order applies are:—cattle plague, contagious pleuro-pneumonia of cattle, foot-and-mouth disease, sheep-pox, sheep-scab, swine-fever, anthrax, epizootic lymphangitis, rabies, glanders and farcy, and sarcoptic and psoroptic mange of horses, asses and mules.

Notification of Disease.—A veterinary surgeon or veterinary practitioner who in his private practice is employed to examine any head of cattle, or any sheep, goat, swine, horse, ass, mule, dog or cat, or the carcase of any such animal, and is of opinion that the animal is diseased, or was diseased when it died or was slaughtered, or suspects the existence of disease therein, shall with all practical speed give notice of the existence, or suspected existence, of disease to an I.L.A., and also, except where the disease is anthrax, sheep-scab, glanders or farcy, or psoroptic or sarcoptic mange of horses, asses or mules, to a constable of the police force for the police area in which the animal or carcase is, or was, at the time of its death, who shall transmit the information by telegram to the B. of A.

An I.L.A., on receipt of notice under this Order, shall report the existence, or suspected existence, of disease to the L.A., and if the disease is anthrax, glanders or farcy, or rabies, also to the M.O.H. of the Sanitary District in which the animal or carcase is, or was, at the time of its death.

The notification of disease hereby prescribed shall be in addition to any notification prescribed by any other Order relating to the disease.

Communication of Information of Disease by one Local Authority to another.—Where a L.A. receives under this Order, or otherwise, information of the existence, or suspected existence, of disease in relation to a carcase of any of the above-mentioned animals that has died or been slaughtered in the district of another L.A., the L.A. shall forthwith transmit the information to the other L.A.

*Fee for Notification.**—A veterinary surgeon or veterinary practitioner who, under and in accordance with this Order, gives notice of the existence, or suspected existence, of disease to an I.L.A. shall be entitled to receive from the L.A. a fee of two shillings and sixpence for each notification.

Where two or more animals or carcases are examined by a veterinary surgeon or veterinary practitioner on the same premises and at the same time and are found to be diseased, one fee only shall be payable to him in respect to the notification of the existence, or suspected existence, of disease in such animals or carcases.

DISEASES OF ANIMALS (DISINFECTION) ORDER, 1906.

Disinfection prescribed in Specified Cases.—The mode of disinfection to be adopted in the case of any place or thing, or part of a place or thing, required to be disinfected under provisions specified shall be as follows:—

The place or thing, or part thereof, required to be disinfected shall be thoroughly coated or washed with:—

(*a*) a 1 per cent. (minimum) solution of chloride of lime containing not less than 30 per cent. of available chlorine; or

(*b*) a 5 per cent. (minimum) solution of carbolic acid (containing not less than 95 per cent. of actual carbolic acid), followed by a thorough sprinkling with limewash; or

(*c*) a disinfectant equal in disinfective efficiency to the above-mentioned solution of carbolic acid, followed by a thorough sprinkling with limewash.

ANTHRAX ORDER OF 1910.

For this Order "Animals" means all ruminating animals, horses, asses, mules, swine and dogs. "Disease" means anthrax.

Notice of Disease.—A person having in his possession or under his charge a diseased or suspected animal or carcase must immediately notify a P.C. of the district. The P.C. is to notify the I.L.A., who has to report to his L.A. The I.L.A. must notify the M.O.H. of the Sanitary District.

Precautions by Occupier in case of Suspected Anthrax.—The occupier must notify the P.C. of the district and must prevent access of animals or fowls to the suspected animal or carcase, or to any part of the premises which has been exposed to infection. He must detain on the premises any diseased or suspected animal, or any other head of cattle, sheep, goat or swine which has been in the same shed, stable, building, yard or field with the diseased or suspected animal or carcase, until it is certified that the animal or carcase was not affected with anthrax, or until such time as any restriction imposed is withdrawn. The occupier must also disinfect as soon as possible with chloride of lime any place where the carcase of a diseased or suspected animal has lain or where its blood has escaped.

Veterinary Inquiry.—A L.A. on receiving information of the suspected existence of anthrax shall cause a V.S. (V.I.L.A.) to inquire into the correctness of the information. The owner and occupier must grant facilities for such inquiry.

If a V.S. is satisfied from an examination of the animal or carcase, or by a microscopical examination of its blood, or by other evidence, that anthrax

* Authority for the payment of fees is provided for by the Diseases of Animals Act, 1909.

does not exist, he must give a certificate to that effect to the L.A., who shall then call off the restriction notice (served by the I.L.A. when the suspicion of the disease is reported to him). If a V.S. is not satisfied that anthrax does not exist he must give a certificate to the L.A. stating that the case is one of *suspected* anthrax. He must take samples of the blood and examine it, and must also forward to the laboratory of the B. of A. two unstained smears of blood and some blood on a sterile swab (these must be sent by parcels' post and the parcel must be labelled "Pathological Material") together with his report.

Precautions by Local Authority in case of Suspected Anthrax.—Where the V.S. gives to the L.A. a certificate that the case is one of suspected anthrax, the L.A. must direct an inspector to carry out such disinfection as may be necessary. The carcase must be forthwith destroyed as hereunder described.

Procedure consequent on Examination by V.I.B.A.—Where the B. of A. certifies that an animal or carcase was diseased, the L.A. shall serve a Notice on the occupier whereon such parts of the premises as are detailed on the notice become an Infected Place for the purposes of this Order. The restrictions thereby imposed remain in force until withdrawn.

Rules affecting an Infected Place.—These rules are printed on the back of the Notice Form and apply to the premises where anthrax has been confirmed as existing by the B. of A., the premises thereby becoming an Infected Place.

(1) The occupier of the infected place shall prevent access of animals to the diseased or suspected animal or carcase or to any part of the premises which has been exposed to infection of disease from the animal or carcase.

(2) Animals shall not be moved, or allowed to stray, out of or into the infected place except as expressly authorised by this article.

(3) Any horse, ass, or mule or dog which is not diseased or suspected may be moved out of the infected place.

(4) Any animal which is not diseased or suspected may be moved out of the infected place to the nearest available slaughterhouse under the supervision of an inspector or other officer of the L.A. for the purpose of being forthwith slaughtered, or with the permission in writing of such inspector, to some premises which shall thereon be made an infected place.

(5) Litter, dung, broken fodder, utensils, pens, hurdles or other things shall not be removed from the infected place except with permission in writing from an I.L.A.

Disposal of Carcases.—Any carcase required by this Order to be destroyed shall be disposed of by the L.A. as follows:—

(1) The carcase to be destroyed by exposure to a high temperature upon the farm or premises upon which the carcase is, or upon the nearest available premises suitable for the purpose; or,

(2) The L.A. may, if authorised by the B. of A., cause the carcase to be destroyed under the supervision of an officer of the L.A. as follows:—The carcase shall be disinfected, and then moved to the premises approved by the B. of A. and there destroyed by exposure to a high temperature or by chemical agents; or,

(3) Where the circumstances do not permit of the disposal by either (1) or (2), the carcase may be buried, as soon as possible, in its skin in a convenient or suitable place to which animals have not access, or which is removed from any dwelling-house, and at such distance from any well or watercourse as will preclude any risk of contamination of the water therein, the carcase to be buried at least six feet below the surface of the earth and with one foot of quicklime both above and below it. Where possible, the burial shall be on the premises where the animal died. A diseased or suspected carcase may not be buried or destroyed otherwise than by the L.A., or be removed from the premises except by the L.A. Before a carcase is moved for burial or destruction all the natural openings thereof must be effectually plugged with some suitable material soaked in a saturated solution of carbolic acid or other equally efficient disinfectant. In no case shall the skin of the carcase be cut, nor shall anything be done to cause the effusion of blood, except by a V.S.

acting under the directions of the L.A., and so far only as may be necessary for the purpose of microscopical or cultural examinations; provided that nothing in this paragraph shall prevent a V.S. on behalf of the owner of the carcase from taking a sample of the blood, or other fluid, or tissue from the carcase for the purpose of microscopical or cultural examination in any case in which neither the history of the case nor any external lesions in the carcase indicate the existence of anthrax.

A L.A. may cause or allow a carcase to be taken into the district of another L.A. for burial or destruction, with the previous consent of that L.A., but not otherwise.

Precautions to be adopted with respect to Milk.—The milk produced by any diseased or suspected cow or goat may not be mixed with other milk, and all milk affected by this article must forthwith be boiled or otherwise sterilised, and any utensil in which such milk is placed before being so treated must be thoroughly cleansed with boiling water before any other milk is placed therein.

Cleansing and Disinfection in case of Anthrax.—The L.A. must at their own expense cause to be cleaned and disinfected under the direction of an inspector, and in the following manner:—(*a*) All parts of a shed, stable, building, field or any other place in which a diseased animal has died or has been slaughtered or has been kept at the date of such death. (*b*) Every utensil, pen, hurdle, &c., used about any diseased animal. (*c*) Every van, cart, &c., used for carrying any diseased animal or carcase on land otherwise than on a railway. Cleansing and disinfection to be carried out as follows:—(1) Every part of a place or thing to be thoroughly soaked or drenched with a 4 per cent. (minimum) solution of carbolic acid (containing not less than 95 per cent. of actual carbolic acid); then (2) the part, if its nature permit, is to be scraped and, where necessary, swept, and the scrapings and sweepings and all dung, sawdust, litter, and other matter to be effectively removed therefrom; then (3) the part to be thoroughly washed or scrubbed or scoured with water, and then disinfected as laid down in the Diseases of Animals (Disinfection) Order.

The scrapings, sweepings, and dung, &c., to be burned or otherwise destroyed, or, if destruction is not practicable, to be well mixed with quicklime and to be effectively removed from contact with animals. The L.A. shall at their own expense cause any litter, dung, or broken fodder, which appears to them or their inspector to be likely to spread disease, to be disinfected thoroughly, or to be burned or destroyed if disinfection is not practicable. If the cost of the disinfection has been increased by any wilful act or neglect on the part of the owner, the L.A. may recover the additional cost.

SWINE FEVER ORDERS, 1908, *et seq.*

Notification.—Persons who have reason to suspect the existence of swine fever among their pigs must report the fact without delay to a P.C. of the district. The P.C. is to notify the B. of A. by telegram, and also report to the I.L.A. who transmits the information to the L.A.

Duty of I.L.A.—On receiving notice of the suspected existence of swine fever, or if he himself suspects that it exists or has existed within 28 days, the I.L.A. must serve a Detention Notice on the occupier of the premises, which thereupon becomes an Infected Place.

Rules for Infected Place.—Swine must not be moved either into or out of an infected place except by licence from the B. of A. Carcases of pigs may be moved if slaughtered and dressed for human consumption, the pigs not being diseased, or suspected of being diseased, or slaughtered as under the Act of 1894; notification with details of removal must be made to the I.L.A. of the district; the stomach and intestines may not be removed except by an officer of the B. of A. or by an I.L.A. for examination or destruction. Litter, dung, utensils, &c., may not be removed except by permission from an officer of the B. of A. or an I.L.A., and then only when such things have been disinfected. No person (except the pig-tender or an authorised person) may enter a sty or enclosure, which is part of an infected place, in which a diseased or suspected

pig is or has been recently kept. Persons leaving such places must wash their hands with soap and water and their boots with disinfectant.

Placing Premises under Movement Restrictions.—In order to prevent the spread of disease a Movement Restriction Notice is served on contiguous premises and on premises containing contact pigs or the dung of suspected pigs.

Rules affecting Premises under Movement Restriction.—Swine may not be moved out of premises except by licence; the movement must be to a specified slaughterhouse or bacon factory; the swine must be marked with an indelible red cross on the loins at least 9 inches long; swine must be carted (except when on a vessel or railway) and must not come in contact with swine not so marked; they must be detained at a slaughterhouse until slaughtered.

The occupier must give notice of death or illness of any pig, unless it is clearly not swine fever.

Swine may not be moved into such premises unless under licence, and then must be kept isolated from other swine on the premises for 28 days.

Disposal of Carcases.—The L.A. is responsible for the disposal of carcases of diseased or suspected pigs, other than that of a pig slaughtered under the Act of 1894 (*i.e.,* pigs slaughtered for diagnosis). Carcases must be buried in their skin and covered with quicklime or other disinfectant and by not less than 6 feet of earth, or they may be cremated on the premises. Under special licence from the B. of A., the L.A. may remove carcases for destruction after they have been disinfected. A carcase of a diseased pig may not be buried or destroyed otherwise than by the L.A. It may not be removed from the premises except for destruction as indicated. If buried, carcases must be so slashed as to render their skins useless.

Cleansing and Disinfection of Infected Premises is to be carried out in the prescribed manner.

Cleansing and Disinfection of Lairs, &c.—Premises such as sheds, yards, sties, &c., used for the temporary lodgment of swine before or after their exposure for sale or exhibition must be cleansed and disinfected at the occupier's expense at least once in 7 days if the place has lodged swine during that period, and at any other time when required by an I.B.A. or I.L.A. For the manner of disinfection see Diseases of Animals (Disinfection) Order, 1906.

Cleansing and Disinfection of Vehicles used in connection with Pig-Dealing.—This section provides for the cleansing and disinfection of vehicles belonging to pig-dealers, and which convey swine along highways. Crates, hampers, &c., used by pig-dealers must also be cleansed and disinfected.

SWINE FEVER ORDER, 1911.

Keeping of Registers by Pig-Dealers, Castrators and Boar Owners.—A pig-dealer must keep a register and enter therein:—Date of purchase of swine, name and address from whom purchased, number and description of swine, date of delivery, date of sale of swine, name and address to whom sold, number and description of pigs sold, date of delivery to purchaser, particulars of any deaths or slaughter or other disposal, other than by sale. A castrator shall enter:—Date of castration of pigs, name and address of owner, number and description of pigs castrated. The owner of a boar used for other sows than his own is to enter:—The date of each service, description of sow, name and address of the owner of sow. Entries must be made within 24 hours of the act which requires entering, and is to be made in ink or indelible pencil. Registers must be produced for inspection if called for by an I.B.A. or I.L.A.

Cleansing and Disinfection by Castrators of Swine.—Any instrument used must be cleansed and disinfected both before and after use. Upon leaving premises the castrator must wash his hands in soap and water and his boots in a suitable disinfectant.

SWINE FEVER ORDER, 1912.

Cleansing and Disinfection of Vehicles, Crates, &c., used for Conveyance of Swine.—Swine exposed for sale in any market-place or other premises where

swine are habitually exposed for sale may not be placed in any vehicle for removal unless and until it has been cleansed and disinfected since it was last used for the conveyance of swine. This does not apply if all the swine placed for removal in the vehicle were brought in it. An I.L.A. may license exemption from disinfection if the vehicle is used solely for the conveyance of swine direct to a slaughterhouse, provided that it is disinfected after each day of its use and after completion of such use. Any vehicle used for conveying swine along a highway must be cleansed and disinfected by the person using it upon receipt of notice from an I.B.A. or I.L.A. The cleansing and disinfection applies to the floor and such parts as may come in contact with the pig or its droppings, and also to hampers, crates, nets, &c.

SWINE FEVER (REGULATION OF MOVEMENT) ORDER, 1908, *et seq.*

For the purpose of controlling the spread of swine fever the B. of A. from time to time make certain "Scheduled Areas" and "Infected Areas." Movement into and out of these areas is carefully controlled, and when such movement is granted it is subject to restrictions such as isolation of the pigs for a period when moved into premises where pigs are kept, and marking of the loins with a red cross when the animals are moved for slaughter.

EPIZOOTIC LYMPHANGITIS ORDER, 1905

Notification of Disease, or suspected disease, is to be made by the usual persons concerned and by a licensed horse-slaughterer, should he find in his possession a carcase of any horse affected with epizootic lymphangitis. The P.C. receiving the information is to telegraph the same to the B. of A. as well as reporting to his L.A.

Restriction of Movement.—A horse which is affected with, or suspected of, the disease, or which has been in contact with a diseased or suspected horse, may not be moved along a highway, &c., whether in a vehicle or not, unless by a licence granted by an I.L.A.

Veterinary Inquiry.—A L.A. has to call in the services of a V.I. or V.S. to test the correctness of the report.

Detention of Horses for Observation.—A L.A. may cause any horse to be detained in any premises for the purpose of observation.

Cleansing and Disinfection.—To follow the usual lines and at the expense of the owner.

Disposal of Carcases.—Carcase to be buried not less than 6 feet deep and covered with a sufficient quantity of quicklime or other disinfectant, or, after disinfection, to be removed to an approved place of destruction. If a carcase is buried its skin is first to be so slashed as to make it useless.

Exemption of Army Veterinary Department and Veterinary Colleges.—Nothing in this Order applies to horses in stables of military barracks or camps, if the horses are under the care and supervision of the Army Veterinary Department, or to horses in stables of any Veterinary College affiliated to the Royal College of Veterinary Surgeons. Provided that nothing in this article shall be deemed to apply to the carcase of any horse, or to exempt a L.A. from any obligation imposed on them in regard to the disposal of carcases.

SHEEP-POX ORDER, 1895.

The suspected existence of this disease has to be telegraphed to the B. of A. by the P.C. receiving the information.

Provision is made for the isolation of infected sheep. The carcase of a sheep that was not affected with sheep-pox may be removed from an infected place by licence of a V.I.L.A. only when it has been skinned. The removal of skin, wool, fleece, &c., is prohibited until these have been disinfected to the satisfaction of the V.I.L.A. Sheep affected with this disease are to be slaughtered by the L.A. within two days of receipt of information that the disease exists.

Sheep suspected of being affected with sheep-pox and those that have been in contact with diseased sheep may also be slaughtered by the L.A. if they think it advisable. Compensation is provided for.

RABIES ORDER, 1919, *et seq.*

Notification.—The suspected existence of this disease is to be reported by the owner of the animal to the P.C. of the district, who, in addition to reporting the fact to his L.A., is to inform the B. of A. by telegraph.

Compulsory Slaughter of Dogs and Cats.—A L.A. shall cause to be slaughtered every dog and cat within their district which is diseased or suspected or which is shown to the satisfaction of the L.A. to have been bitten by a diseased dog or cat.

Owners to give Facilities for Slaughter.—The owner or person in charge of a dog or cat to which the above article applies must give all reasonable facilities for carrying out the Order.

Veterinary Inquiry.—A L.A., on receiving information as to the suspected existence of rabies, must cause a veterinary inquiry to be made as to the correctness of the report. The V.I. is to make a report to the B. of A. A L.A. is to have a post-mortem examination made by the V.I., who is to forward such material to the B. of A. as they may require. The owner of the animal is to give facilities for the examination.

Isolation of Dogs and Cats Exposed to Infection.—The L.A. is to cause the isolation of any dog or cat which has been exposed to the infection of rabies, or any other animal which is diseased or suspected or has been exposed to the infection of rabies, by the issue of a Detention Notice.

Every dog, cat or other animal shall for the purpose of this article be deemed to have been exposed to the infection of rabies which has been in the same shed, stable or building, kennel, field or other place, or otherwise in contact with any diseased or suspected dog or cat, or which has in any other way been exposed to the infection of rabies.

Disposal of Carcases.—Carcases to be buried in their skins, not less than 6 feet below the surface of the earth and covered with quicklime or other disinfectant, or be cremated or be removed to an approved place of destruction for destruction by cremation or by chemicals. If buried, the skin is to be so slashed as to make it useless.

Disinfection.—Any kennel, pen, sty, or other enclosure used by a diseased or suspected animal, and anything so used, such as litter or bedding, or feeding or drinking utensil, hurdle or sleeping basket, and anything whatsoever contaminated by the saliva of a diseased or suspected animal before or after its death, shall be disinfected by the owner or occupier or person in charge as follows:—

The enclosure or thing shall, if not forthwith destroyed by burning, be immersed in boiling water for not less than 10 minutes; or be immersed or soaked or drenched in or with a suitable disinfectant.

RABIES (AMENDMENT) ORDER, 1919.

Isolation of Dogs and Cats pending Slaughter or Veterinary Inquiry.—Every person who shall have given notice of the suspected existence of rabies in a dog or cat shall:—

(*a*) Detain and isolate the dog or cat in a kennel, shed or other building, and shall not permit any other animal to come in contact therewith until the L.A. shall either cause the dog or cat to be destroyed or notify the person that the animal was not affected with rabies.

(*b*) Detain and isolate in a kennel, shed or other building any dog or cat which has been in the same kennel, shed or building, or otherwise in contact with the animal to which the notice of the disease is related, until receiving notice from the L.A.

Nothing in this article shall prevent the owner from slaughtering at any time any dog or cat to which this article relates.

RABIES (LANDING OF DOGS) ORDER, 1919.

Exclusion of Ports, &c., from Scheduled Areas or Districts.—A port, harbour, creek or dock wholly or partly situate in or adjoining an area or district out of which the movement of dogs is prohibited by an Order shall be deemed to be wholly excepted from the area or district.

Restriction of Landing of Dogs.—The provisions of this article apply to any dog which at any time within the last preceding six months has been on board a vessel in any port, harbour, &c., to which the above article applies.

A dog to which this article applies shall not be landed from any vessel at any place which is not within an area or district out of which the movement of dogs is prohibited.

A dog to which this article applies shall at all times while on board a vessel in any port, harbour, &c., in Great Britain be:—(*a*) secured to some part of the vessel, or led by a collar and chain, and muzzled with a wire cage muzzle so constructed as to render it impossible for such dog while wearing the same to bite any person or animal, but not so as to prevent such animal from breathing freely or lapping water; or (*b*) confined in an enclosed part of the vessel from which the dog cannot escape.

If any dog to which this article applies shall die, or be lost from a vessel, in any port in Great Britain, the person in charge of the dog shall forthwith give notice to the B. of A.

PARASITIC MANGE ORDER, 1911 AND 1918.

Definition of Parasitic Mange.—"Parasitic Mange" means sarcoptic mange or psoroptic mange in a horse, ass or mule.

Detention and Treatment of Animals.—A V.I.L.A. serves a Notice on the occupier of any premises in which there is an animal, which, in his opinion, is affected with mange, when the following restrictions take effect:—

(1) Each animal on the premises which is affected with mange shall from time to time, as often as may be necessary, be treated by the owner with some dressing or other remedy for such disease approved for the purpose by a V.I.L.A., or by a V.S., employed by the owner of the animal to examine it.

(2) Any animal on the premises which is affected with mange shall not be moved out of the stable, field, or other premises specified in the Notice except with a licence of a V.I.L.A. or I.L.A. acting under the advice of a V.I., and in accordance with the following conditions:—

(*a*) The animal may be moved only by road.

(*b*) The animal may be moved to a knacker's yard or slaughterhouse for the purpose of slaughter thereon, or to a place of detention to be treated in accordance with the provisions of the Order.

(*c*) If the animal is certified by a V.I. to be affected only with psoroptic mange, it may also be moved from and to the premises specified in the Notice for the purpose of being worked.

(*d*) If the animal is not so certified, it may be moved between the premises specified in the Notice and premises in the occupation of the owner of the animal for the purpose of being worked thereon.

(*e*) Before the movement the animal shall be treated with some dressing or other remedy approved as aforesaid.

(*f*) Where the animal is certified to be affected only with psoroptic mange, the movement may take place at any time within 7 days after being so treated, but if the animal is not so certified the treatment shall be applied immediately before the movement.

(*g*) In the case referred to in (*c*) and (*d*) the movement must not cause an absence from the premises specified in the Notice for a period exceeding twenty-four hours, and the animal must not be moved into any stable, shed, field or other premises in which horses, asses or mules are kept.

(3) Any other horse, ass or mule on the premises at the date of the service of the Notice shall only be moved out of the stable, shed, field or other premises if within the preceding 7 days its skin has been treated all over with some approved dressing. Provided that this paragraph shall not apply to any horse, ass or mule in a market, fairground or sale-yard.

(4) No animal (horse, &c.) shall be allowed by the owner to stray out of the stable or other premises specified in the Notice or from land on which it is being worked.

Cleansing and Disinfection.—(1) Any place in which an animal affected with or suspected of parasitic mange has been at any time shall, if and when so required by an I.L.A., be cleansed and disinfected by, and at the expense of, the occupier of such place, as follows:—

(*a*) The place shall be swept out, and the sweepings shall forthwith be burned or be well mixed with quicklime and be effectually removed from contact with horses, asses or mules; and

(*b*) The floor of the place and all other parts thereof with which such animal has come in contact shall, as far as practicable, be disinfected in accordance with the subsequent provisions of this article; then

(*c*) The same parts of the place shall be thoroughly washed, scrubbed or scoured with water.

(*d*) In the case of a field or other place which is not capable of being so cleansed and disinfected, it shall be sufficient if such field or place be cleansed or disinfected as far as practicable, and to the satisfaction of an I.L.A.

(2) Every utensil, manger, feeding-trough, pen, hurdle, clothing, harness or other thing used for or about a horse, ass or mule affected with, or suspected of, parasitic mange shall, as soon as practicable after being so used, and before being so used for any other horse, ass or mule, be cleansed by being thoroughly washed or scrubbed or scoured with water, and subsequently disinfected in accordance with the provisions of this Order, and at the expense of the owner of the thing.

(3) Every place or thing, or part thereof, required by this article to be disinfected shall either be thoroughly coated or washed with:—

(*a*) a 4 per cent. (minimum) solution of carbolic acid containing not less than 95 per cent. of actual carbolic acid; or

(*b*) a disinfectant for mange equal in disinfective efficiency to the above-mentioned solution of carbolic acid; or

(*c*) shall be effectively exposed to an atmosphere of gas poisonous to the parasites of parasitic mange.

Exemption of Army Veterinary Service and Veterinary Colleges.—Nothing in this Order applies to horses, asses or mules which are the property of the Crown, or are in stables of military barracks or camps or under the care and supervision of the Army Veterinary Service, or to horses, asses or mules in stables of any Veterinary College affiliated to the Royal College of Veterinary Surgeons.

GLANDERS OR FARCY ORDER OF 1907.

Definitions.—"Disease" means Glanders or Farcy. A "diseased" horse, ass or mule means one in which the clinical symptoms are definite evidence of disease, or in which the application of the Mallein Test has resulted in definite evidence of disease.

A "suspected" animal is one which shows clinical symptoms of disease, but where such symptoms are insufficient to make the animal a "diseased" animal.

Notification of the suspected existence of glanders must be made to a P.C. by the owner (and by a V.S.) and by a horse-slaughterer should he find a suspected carcase in his possession. Notification is made by the P.C. to his I.A. and to the M.O.H. of the district.

Public Warning.—A L.A. may give public warning of the existence of this disease in any place.

Slaughter of Diseased Animals.—A L.A. must cause any diseased animal to be slaughtered without delay.

Detention and Treatment of Incontact Animals.—This article provides for the isolation of incontact animals. The L.A. may, with the written consent of the owner, apply the Mallein test to any incontact animal (horse, ass or mule), and shall apply the test as soon as practicable after being so requested by the owner. The application of the test shall be made by the V.I.L.A. If the test gives a positive reaction the L.A. must cause the animal to be slaughtered. If the reaction is indefinite, the test must be re-applied not later than 12 days after the first test.

Appeal to the Board against Order for Slaughter.—If the owner of an animal objects to it being slaughtered, the L.A. must not have it slaughtered except with the special authority of the B. of A.

Post-Mortem Examination of Slaughtered Animals.—A post-mortem examination must be made on every animal where the clinical symptoms did not afford definite evidence of disease. Notice of the intended examination must be given to the owner so that he may ask his own V.S. to be present. In the event of disagreement with the findings of the V.I.L.A. the latter must forward suitable material to the B. of A.

Compensation for Slaughter.—If the post-mortem examination shows that the animal was not affected with glanders, the full value of the animal at the time of the application of the test is payable, with a limit of £50 per horse, or £12 for an ass or mule. Where the post-mortem examination is positive, one-half the value is payable with a limit of £25 or £6.

Where no post-mortem examination is held, the L.A. may pay what they think fit, with a minimum of £2 for a horse and 10s. for an ass or mule. If above the minimum, the sum may not exceed one-quarter of the value of the animal before it became diseased.

Cleansing and Disinfection.—Follow the usual lines.

Disposal of Carcases.—By burial or destruction in an approved place as for other scheduled diseases.

Exemption of Army Veterinary Department and Veterinary Colleges.—Nothing in this Order applies to horses, asses or mules in stables of military barracks or camps or in vessels, if the animals are under the care of the Army Veterinary Department, or to horses, asses or mules in stables of any Veterinary College affiliated to the Royal College of Veterinary Surgeons: Provided that nothing in this article shall be deemed to apply to the carcase of any horse, ass or mule, nor to exempt a L.A. from any obligation imposed on them in regard to the disposal of carcases.

Note.—Since going to press the *Glanders or Farcy Order of* 1920 has been issued. That of 1907 is revoked. Under the new Order a higher scale of compensation is provided for, and specially so if the horse owner can prove that the affected horse while in his possession, and within twelve months before the date when notice of disease was given, had been tested with mallein and had not reacted.

FOOT-AND-MOUTH DISEASE ORDER, 1895.

A P.C. on receiving notice of the suspected existence of this disease must telegraph the B. of A. as well as reporting to his L.A. The L.A. must obtain the services of a V.S. for the purpose of inquiring into the correctness of the report.

Inspectors and others on leaving the infected premises must wash their hands with soap and water and disinfect their boots.

All movement from and to the infected premises is prohibited, unless under licence. Carcases of animals that have died of the disease must be buried under the authority of the L.A. in quicklime or other disinfectant. The carcases must be so slashed as to render their hides useless, or moved after disinfection

to an approved place for destruction. Infected and incontact cattle, sheep, and swine are slaughtered and compensation is paid to the owner.

PLEURO-PNEUMONIA ORDER, 1895, AND CATTLE-PLAGUE ORDER, 1895.

The procedure with either of these diseases is similar to the above.

Carcases are to be buried in their skins, which are to be so slashed as to make them useless, or the carcases may be removed to an approved place of destruction. Diseased and incontacts are slaughtered and compensation is paid to the owners.

FOOT-AND-MOUTH DISEASE (CONTROL OF MOVEMENT) ORDER, 1920.

This Order applies to two areas—(1) a Scheduled District; and (2) a Prohibited Area. A Prohibited Area is a defined area contained within a Scheduled District.

The Order is divided into four parts.

Part 1 prohibits the movement into, out of, or within a Scheduled District of any cattle, sheep, goats or swine, except by railway when passing through the district. Power is granted to an inspector of the ministry or of a L.A. to restrict the movement of persons into fields, sheds, &c., containing animals mentioned above. Power is also given to restrict the movement of poultry and dogs where necessary.

A Scheduled District means a district to which Part 1 of this Order is applied by an Order of the Ministry.

Part 2 provides for the movement of animals into a Scheduled District for immediate slaughter.

Part 3 makes provision for the movement of animals for slaughter in a Scheduled District, excluding such part of it as may be defined as a Prohibited Area. Markets and sales where the animals are intended for immediate slaughter may be sanctioned by the L.A. within a Scheduled District, but not in a Prohibited Area. Veterinary inspection and marking of animals so exposed for sale is required.

Part 4 defines the conditions under which movement licences are granted and specifies the methods by which animals are to be marked.

EPIZOOTIC ABORTION ORDER, 1920.

This Order gives power to L.As. for the purpose of preventing the spread of epizootic abortion, to make Regulations (1) to prohibit the exposure by any person in a market, fairground or sale-yard, within the district of the L.A., of a cow or heifer which to his knowledge, or according to information furnished to him, has calved prematurely within two months immediately preceding such exposure; (2) to prohibit the sale by any person of a cow or heifer as above defined, unless before the sale he shall have given to the purchaser notice in writing of such premature calving.

SHEEP-SCAB ORDER, 1920.

Notice of Disease and Detention.—A person owning or in charge of a sheep suspected to have sheep-scab must report the fact to a P.C. of the area who shall report to an I.L.A. A V.S. has to notify an I.L.A.

A Detention Notice is served on the owner of the sheep by the I.L.A., on which sheep may not be moved into or out of the premises nor may other sheep come in contact with the suspected sheep. No carcase of a sheep, or any skin, fleece or wool separate from the carcase of a sheep, or dung, fodder, litter or other thing that has been in contact with the detained sheep may be moved from the

place without permission from the I.L.A. Any skin, fleece or wool must be disinfected before removal by being soaked in sheep-dip. An I.L.A. may license sheep for removal to a slaughterhouse if the sheep are marked with a red cross on the loins. The fleeces of such sheep slaughtered in a slaughterhouse may not be removed until they have been dipped in sheep-dip. Necessary movement of detained sheep, such as for feeding, isolation, &c., may be done by licence from the I.L.A.

When a L.A. receives information that sheep-scab is suspected to exist a V.S. must be called in to examine the sheep.

Treatment of Sheep under Detention.—Where a Detention Notice is in force the sheep must be thoroughly dipped at least twice in an efficient sheep-dip with an interval of not less than 7 days and not more than 14 days between the dippings in the presence and to the satisfaction of an I.L.A. An I.L.A. may cause further treatment of the sheep, but sheep that have been dipped as required are not required to be dipped until after the expiration of 7 days.

Power to serve Isolation and Dipping Notices.—An I.L.A. may serve an Isolation Notice on the owner of any sheep which he has reason to believe have been in contact with any sheep affected with or suspected of sheep-scab, or which have otherwise been exposed to the infection of sheep-scab. The sheep to which this Notice relates may not be moved from the premises except by licence of an I.L.A., nor be permitted to stray from the premises, nor come in contact with other sheep. An I.L.A. is to serve a Dipping Notice requiring incontact sheep to be dipped twice with an interval of not less than 7 days and not more than 14 days.

Certificate of Dipping.—Where sheep are dipped in the presence and to the satisfaction of an I.L.A., he is to give the owner a certificate to that effect.

Disinfection for Sheep-Scab.—Any place in which a sheep affected with sheep-scab has been kept, and all utensils, pens, hurdles, &c., are to be cleansed and disinfected by and at the expense of the owner or occupier of the place as follows:—The floor and all parts of the place and all litter, &c., shall be saturated with carbolic acid or other suitable disinfectant, then swept out and all litter, wool, &c., buried or effectively destroyed. In the case of a field, yard, &c., the fragments of wool are to be collected and destroyed and rubbing-places disinfected. All utensils, pens, hurdles, &c., are to be swabbed with a solution of carbolic acid or other suitable disinfectant.

Regulations of Local Authorities.—A Local Authority may, with a view to preventing the spreading of sheep-scab, make Regulations requiring sheep to be dipped that have moved into their district unless to a sale-yard, fair, &c., or to a temporary place of detention for not more than 7 days, for regulating the movement of sheep that have been moved to a place of detention in their district from without, and for the occupier to notify the arrival of the sheep; for regulating the movement of sheep within their district; for prescribing, regulating, and securing the periodical treatment of all sheep in their district by effective dipping in an efficient sheep-dip; and for requiring every sheep-dealer to keep a register with such particulars of his purchases and sales of sheep as may be prescribed by the Regulations. Regulations made by a L.A. have to be submitted to the Ministry of Agriculture for approval.

Prohibition to Expose or Move Sheep affected with or suspected of Sheep-Scab.—The usual restrictions on the movement of diseased or suspected animals or their exposure in markets, fairs, highways, &c., are enforced. Diseased or suspected sheep that are exposed in contravention to the requirements of the Order may be seized and dealt with by the L.A.

Approval of Sheep-Dips for Sheep-Scab.—A sheep-dip prepared in accordance with any of the prescriptions specified below is to be regarded as a sheep-dip approved by the Minister of Agriculture, and a sheep-dip contained in a package or vessel marked with a statement or indication that the dip has been so prepared is also regarded as an approved dip.

Sampling of Dips.—Where sheep are required to be dipped, the person who dips the sheep must supply to the I.L.A. on request a sample of the dip or allow the inspector to take one, and must give to the inspector particulars asked for concerning the dip.

Mixing of Dips.—The bath in which sheep are dipped must contain at least one efficient dip in the proportions at which the dip is approved. Where two or more dips are used the total volume must not be more than is required for the dilution of one of the dips in the proportions approved.

PRESCRIPTIONS FOR SHEEP-DIPS APPROVED BY THE MINISTER FOR SHEEP-SCAB.

Quantities for 100 gallons of bath.

1. *Lime and Sulphur.*

Mix 18 lbs. of flowers of sulphur with 9 lbs. of good quick-lime. Slake the lime and make into a paste with the sulphur. Place the mixture in a strong cloth, tie the ends and suspend in a boiler containing 10 gallons of water so that the water completely covers the contents of the cloth. The cloth must not touch the sides or bottom of the boiler, as otherwise the cloth may be burned and its contents escape. Boil for two hours, then remove the cloth, taking care that none of its contents escape into the water, and throw the solids away. Make up to 10 gallons again with additional water and put the liquid into a tight drum or barrel. This quantity is sufficient when mixed with water to make 100 gallons of dipping bath.

2. *Carbolic Acid and Soft Soap.*

Dissolve 5 lbs. of good soft soap, with gentle warming, in 3 quarts of liquid carbolic acid (containing not less than 97 per cent. of real tar acid). Mix the liquid with enough water to make 100 gallons.

3. *Tobacco and Sulphur.*

Steep 35 lbs. of finely-ground tobacco (offal tobacco) in 21 gallons of water for 4 days. Strain off the liquid, remove the last portions of the extract by pressing the residual tobacco. Mix the whole extract, and to it add 10 lbs. of sulphur. Stir the whole mixture, and make up the total bulk to 100 gallons with water.

Note:—The period of immersion in these dips should not be less than half a minute.

SHEEP (DOUBLE DIPPING) ORDER, 1920.

Application of Order.—Two Areas are defined in this Order, a "Movement Area" and a "Double Dipping Area."

Restriction on Movement of Sheep out of a Movement Area.—Sheep may not be moved out of a Movement Area unless by licence of an I.L.A. of the district in which the sheep are when the licence is granted, unless the inspector is satisfied that the sheep are intended for immediate slaughter, and that it is impracticable for the sheep to be dipped before movement, or that the sheep are to be moved direct to a slaughterhouse. A licence for movement may only be granted, subject to certain conditions, if within 28 days before the licence is granted the sheep have been dipped twice with an interval of not less than 7 and not more than 14 days between the dippings.

Provision for Movement through Movement Area by Road or Railway.—Sheep are not considered to be moved out of a Movement Area when they are moved through such an Area by railway or road, or partly by rail and partly by road, from a place outside such Area to another place outside such Area, provided that they are moved through the Area without unnecessary delay and are kept separate from all sheep in the Area during the movement, and also provided that when moved by road they are accompanied by licence of an I.L.A. of the district of the place where the sheep enter the Area.

Movement of Irish Sheep.—Sheep landed from Ireland in a Movement Area are not considered to be moved out of a Movement Area if they are consigned to a destination outside the Area and are moved by the most direct route.

Double Dipping Area.—All sheep which are in a Double Dipping Area

within a "double dipping period" must be dipped twice within the Area, with an interval of not less than 7 days and not more than 14 days. In the case of sheep moved into the Area within 14 days before the expiration of the double dipping period, it is sufficient if they are dipped twice within 17 days after the movement. For the purpose of enabling the L.A. to be present at the dipping when they think it desirable to be present notice of the intended dipping must be given to the L.A. All sheep after their second dipping shall during the remainder of the double dipping period be kept, as far as practicable, isolated from sheep which have not been so dipped.

Restriction on Exposure of Sheep at Markets, &c., within the Double Dipping Area during Double Dipping Period.—Sheep in a Double Dipping Area may not enter a sale, market, exhibition, &c., in a Double Dipping Area during the double dipping period, unless they have within 28 days before the date of entry been dipped twice on separate dates, with an interval of not less than 7 days and not more than 14 days between the two dates, and accompanied with a certificate that they have been so dipped, and that since the second dipping have been kept separate from other sheep.

TUBERCULOSIS ORDER, 1914.

(AT PRESENT SUSPENDED.)

Notice of Disease.—A person having in his possession or under his charge:—(1) any cow which is, or appears to be, suffering from tuberculosis of the udder, indurated udder or other chronic disease of the udder; or (2) any bovine animal which is, or appears to be, suffering from tuberculous emaciation; or (3) any bovine animal which is suffering from a chronic cough and showing definite clinical symptoms of tuberculosis, shall give information of the fact to a P.C.

Notification of Disease by Veterinary Surgeons.—In accordance with the Animals (Notification of Disease) Order, 1919.

Examination of Animals, &c.—The L.A. shall, where, owing to information received or otherwise, there is reasonable ground for supposing that on any premises in their district there is an animal affected as above, direct a V.I. to examine the diseased or suspected animal and any other bovine animals on the premises which he may consider it desirable to examine for diagnostic purposes in connection with the conditions defined above. The inspector may, with the previous written consent of the owner, apply the tuberculin test. The V.I. may examine any bovine animal on the premises, require any cow to be milked in his presence, take samples of the milk, and he may require the milk from any particular teat to be kept separate. He may take samples of the fæces or urine of any bovine animal on the premises or of any abnormal discharge.

Slaughter of Diseased Animals.—When the V.I. reports that there is an animal which is suffering from tuberculosis of the udder, or tuberculous emaciation, or giving tuberculous milk, or suffering from a chronic cough and showing definite clinical signs of tuberculosis, the L.A. shall notify the owner of the animal in writing, and also the Ministry of Agriculture, and shall cause the animal to be slaughtered; but if the owner of the animal objects to it being slaughtered the L.A. may not have it slaughtered without the special authority of the Ministry. If the value of the animal exceeds £30 it may not be slaughtered unless so directed by the Ministry.

Valuation for Compensation.—Before slaughter the market value of an animal shall be determined by agreement between the L.A. and the owner, or, if they fail to agree, by a valuer.

Post-Mortem Examination of Slaughtered Animals.—The L.A. must have every carcase examined by the V.I.L.A., or, if required by the owner, by another veterinary surgeon.

Compensation.—If no examination is made, or if the examination fails to show that the animal was suffering from tuberculosis, the L.A. is to pay the owner the full market value of the animal plus 20s. If the examination shows that the animal was suffering from tuberculosis (not being advanced tuberculosis)

the owner is to be paid three-fourths of the market value, or 30s., whichever sum is the greater, after deducting one-half of the reasonable costs of the valuation of the animal and the examination of the carcase. If it is found that the animal was suffering from advanced tuberculosis, the compensation is to be one-fourth of the value, or 30s., less the above deductions.

In this Order, advanced tuberculosis means (*a*) when there is miliary tuberculosis of both lungs; (*b*) when tuberculous lesions are present in the pleura and peritoneum; (*c*) when tuberculous lesions are present in the muscular system, or in the lymphatic glands, embedded in or between the muscles.

If salvage of the carcase exceeds the value paid for compensation, the excess received by the L.A. is to be given to the owner.

Precautions with respect to Milk, &c.—The milk from any cow diseased, as defined above, is not to be mixed with other milk until the cow has been examined by a V.I., and until either three clear days after the examination have expired or the owner or person in charge has been notified that this article has ceased to apply to the cow; and all milk affected by this article shall be boiled or otherwise sterilised, and milk utensils cleansed with boiling water. These provisions also apply to the milk of a cow that is to be slaughtered. The provisions of this article may also be applied to the milk of any cow suspected of giving tuberculous milk.

Detention and Isolation of Suspected Animals.—See other scheduled diseases.

Suspected Animals in Markets, Fairs, &c.—A V.I. may cause an animal suspected to be diseased to be removed for subsequent examination.

Cleansing and Disinfection of premises on which there has been a diseased animal must be done by the owner at his own expense.

PROTECTION OF ANIMALS ACT, 1911.

This Act provides protection for animals from ill-treatment, such as beating, kicking, over-riding, over-loading, torturing, or terrifying, &c. It also prohibits the causing of fighting or baiting of animals and the administration of poisons to animals without reasonable cause or excuse. The destruction or preparation for destruction of any animal as food for man does not come within the scope of this Act, unless unnecessary suffering is inflicted. Neither does the coursing or hunting of any captive animal, unless such animal is liberated in an injured, mutilated, or exhausted condition. If the owner of an animal is convicted of an offence of cruelty, the Court may order the destruction of the animal, if satisfied that it would be cruelty to keep it alive; or the Court may deprive the convicted person of ownership of the animal and dispose of it as they may think fit.

Knackers.—A person licensed to slaughter horses may not carry on the trade of a horse dealer. A knacker must have his name with the word "knacker" affixed over his yard gate. He must cut off the hair from the mane of any horse, ass or mule directly such animal has been delivered to him. Slaughter must take place within two days of delivery; all animals must be properly fed and watered on delivery. No animal may be used for work of any kind. A knacker must keep a register for the entry of the description of animals delivered and the name and address of the owner. No person under 16 years of age may be admitted to a knacker's yard during the slaughtering and cutting up of the carcase of any animal. No animal may be killed in the sight of another waiting slaughter. A knacker may not part with alive any animal which has been delivered to him.

Poisoned Grain and Flesh, &c.—The selling or giving away of grain which has been rendered poisonous, except for *bona fide* use in agriculture, is illegal. It is also forbidden to place in or upon any land or building any poison or poisonous matter (except sown seed or grain), unless placed for the purpose of destroying rats and other small vermin, and that reasonable precautions are taken to prevent access to it of domestic animals.

The Use of Dogs for Draught on any public highway is forbidden.

Inspection of Traps.—Spring traps set for the purpose of catching rabbits or hares must be visited at least once between sunrise and sunset.

Injured Animals.—If a P.C. finds any animal (horse, mule, ass, bull, sheep, goat or pig) so diseased, severely injured, or in such a physical condition that, in his opinion, having regard to the means available for removing the animal, there is no possibility of removing it without cruelty, he shall, if the owner be absent or refuse consent to its destruction, summon a V.S., and on his certificate may cause the animal to be slaughtered without the owner's consent.

THE PROTECTION OF ANIMALS (SCOTLAND) ACT, 1912.

This is in substance the same as the above.

POULTRY ACT, 1911.

This is an Act to enable Orders to be made under the Diseases of Animals Acts for protecting live poultry from unnecessary suffering, and for other purposes connected therewith. The Diseases of Animals Act, 1894, is, by this Act, to have effect for the purpose of protecting poultry from unnecessary suffering while being conveyed by land or water, and in connection with their exposure for sale, and their disposal after sale, and for requiring the cleansing and disinfection of receptacles or vehicles used for the conveyance of live poultry. For the purposes of an Order made under this Act the word "animals" is to include live poultry. "Poultry" includes domestic fowls, turkeys, geese, ducks, guinea-fowls and pigeons.

CONVEYANCE OF LIVE POULTRY ORDER, 1919.

Protection of Poultry during Conveyance by Water.—The conveyance of poultry on a vessel to or from a port in Great Britain shall comply with the following conditions:—

(1) The poultry shall, while on board or on premises of a shipping company in connection with their conveyance by water, be protected as far as practicable from exposure to bad weather or sea water or excessive heat.

(2) Shall be carried only in such parts of the vessel as are sufficiently ventilated, and receptacles containing the poultry shall be disposed so as to allow sufficient ventilation to reach each receptacle, and so as to afford access to each receptacle for inspection of the poultry as occasion may require.

(3) Receptacles containing poultry shall be secured so as not to be liable to be shifted by the motion of the vessel.

(4) A receptacle containing poultry may be placed on another only if sufficient ventilation is left for each.

(5) The poultry, whether carried in receptacles or otherwise, shall not be so overcrowded as to cause injury or unnecessary suffering.

If any head of poultry while on a vessel or on the premises of a shipping company is found to be so injured that, in the opinion of the master or a superior officer of the shipping company, the destruction of the bird is desirable to prevent unnecessary suffering, the master or officer may cause it to be killed.

Protection of Poultry during Conveyance by Railway.—The conveyance of poultry by railway in Great Britain shall comply with the following conditions:—

(1) While on a truck or other vehicle, or on the premises of a railway company for conveyance, shall be protected as far as practicable from exposure to bad weather or excessive heat.

(2) Every railway truck or other vehicle in which poultry are conveyed shall be sufficiently ventilated.

(3) Receptacles containing poultry shall be so disposed as to allow sufficient ventilation to reach each one and so as to afford access to each.

(4) Receptacles shall be secured so as not to be liable to be shifted during transit.

(5) As (4) above.

(6) As (5) above.

Injured poultry may be killed by the station-master or other superior officer of the company.

Protection of Poultry during Conveyance by Road or Exposure for Sale.—Poultry, while being conveyed by road or exposed for sale or while in a market or other place where poultry are habitually exposed for sale, shall in Great Britain:—

(1) Be protected as far as practicable from exposure to bad weather or excessive heat; and

(2) Not be confined in a receptacle which is not of a height and size reasonably sufficient for the poultry and the number contained therein, or which is so constructed as to be likely to cause injury or unnecessary suffering to poultry confined therein or which does not allow sufficient ventilation, but this shall not be deemed to prohibit the conveyance of poultry in "swills" or shallow baskets having a net over the top with mesh sufficiently small to prevent protrusion of the heads of the poultry; and

(3) Not unnecessarily be tied by the legs or be allowed to remain so tied for a longer period than is necessary; or unnecessarily be carried head downwards.

Conveyance of Unfit Poultry.—Poultry shall not be permitted, by the owner or person in charge, to be conveyed on a vessel from a port in Great Britain to any other port or by railway or by road in Great Britain, if from any injury or any other cause such conveyance of the poultry may reasonably cause unnecessary suffering to them.

Use of Unsuitable Receptacles.—Poultry may not be conveyed in a receptacle or portion of one which is not of a height and size sufficient to protect the birds, or which is so constructed as to cause unnecessary suffering, or which does not allow sufficient ventilation, or, in the case of conveyance by vessel or by railway, or by public carrier which is not so constructed as to protect the poultry from injury by protrusion of the head, legs or wings through the top or bottom or sides of the receptacle. This article does not prohibit the use of "swills" or shallow baskets having a net over the top with mesh sufficiently small to prevent protrusion of the heads of the poultry.

A receptacle shall be deemed to be so constructed as to be likely to cause injury or unnecessary suffering, for the purposes of this article, if it measures more than 24 square feet, or if any compartment measures more than 10 square feet, or if the receptacle is not sufficiently strong and rigid for the purpose for which it is intended to be used.

Mixed Consignments.—Turkeys, geese and ducks, which are placed in the same receptacle with other poultry, shall not be conveyed from a port in Great Britain or by railway in Great Britain, unless the turkeys or geese or ducks are in a separate compartment.

Handling of Receptacles containing Poultry.—Receptacles containing poultry shall, during conveyance on a vessel, railway truck or other vehicle, or while being loaded or unloaded, be lifted, carried and deposited with care and in such manner as to avoid injury or unnecessary suffering being caused to the poultry.

Confining of Poultry in Receptacles for Unnecessary Time.—Any person who in Great Britain, in connection with the conveyance of poultry belonging to him or being under his charge, shall cause or permit the same to be confined in a receptacle for a time longer than is necessary, shall be guilty of offence against the Act of 1894.

Cleansing of Receptacles.—A receptacle which has been used for the conveyance of poultry by land or water to any place in Great Britain shall be thoroughly cleansed by the owner or person in charge thereof before being again so used, and if sent by railway or vessel before being so sent.

Feeding, &c., of Poultry in Exceptional Circumstances.—Where the conveyance of poultry by vessel or railway has been so protracted by exceptional causes as to render it necessary to supply the poultry with food or water in order to protect them from unnecessary suffering, the master of the vessel or the railway company shall cause the poultry to be supplied with sufficient food and water.

THE DOGS ACT, 1871, *et seq.*

This is an Act to provide protection against dogs. On a complaint being made that a dog is dangerous, to either persons or animals, and not being kept under proper control, any Court of summary jurisdiction, if it thinks that the dog is dangerous, may order it to be kept under proper control, or, without such option, to be destroyed. The penalty for failing to carry out the order of the Court may not exceed 20s. for each day.

If a mad dog, or a dog suspected of being mad, is found within their jurisdiction the L.A. may make an Order placing restrictions on all dogs not under control.

DOGS ACT, 1906.

The owner of a dog is liable in damages for injury done to cattle by the dog, and it is not necessary for the person seeking damages to show a previous mischievous propensity, or to show that the injury was due to neglect on the part of the owner. Where a dog is proved to have injured cattle or chased sheep it may be dealt with as a dangerous dog.

This Act grants power to the B. of A. to make Orders for the following purposes:—For dogs to wear a collar bearing the name and address of the owner when out in public; to prevent the worrying of cattle by dogs and also to prevent dogs from straying between sunset and sunrise. Any dog in respect of which an offence is being committed against these Orders may be seized and treated as a stray dog.

When a P.C. suspects any dog found in public as being a stray dog he may seize and detain it until the owner has paid all expenses incurred. If a dog so seized has a collar bearing the address of the owner, or if the owner is known to the officer, he shall serve a notice requiring the owner to call for the dog within 7 days; it may be sold or destroyed if not called for within that period. No dog seized by the police may be given or sold for the purpose of vivisection. The police must keep a register of all dogs seized with particulars concerning them, unless they are transferred to premises for the reception of stray dogs, and no dog may be transferred to such an establishment unless a register is kept there. Any person having charge of a seized dog must cause it to be properly fed and maintained.

Any person taking possession of a stray dog must either return it to the owner, or notify the police, stating where the dog was found, give a description of it, and state where it is being detained. Any person failing to give such notice is liable to a fine not exceeding 40s.

Burying of Carcases.—Any person who knowingly and without reasonable excuse permits any head of cattle to remain unburied in a place to which dogs can gain access is liable to a fine not exceeding 40s.

For this Act "cattle" includes horses, mules, asses, sheep, goats and swine.

DOGS ORDER OF 1906.

Regulation of L.A. as to Wearing of Collars by Dogs.—A L.A. may make regulations for the wearing by dogs, while in a highway or place of public resort, of a collar with the name and address of the owner inscribed on it. Such regulation shall not apply to packs of hounds, to dogs while being used for sporting purposes, or for the capture of vermin or the tending of sheep or cattle.

Any dog in respect of which an offence is being committed may be seized and treated as a stray dog as under the Act of 1906.

HORSE BREEDING ACT, 1918.

This is an Act to regulate the use of stallions for stud purposes. No person may travel or exhibit a stallion with a view to its use for service unless it has

been licensed under this Act. The Board of Agriculture has power to grant, revoke or suspend licences.

The Board may refuse to grant a licence and may revoke or suspend a licence if it appears that the stallion is affected with any contagious or infectious disease; is affected with any other disease or defect prescribed as a disease or defect rendering the stallion unsuitable for service of mares; or has proved to be inadequately prolific; or is calculated, if used for stud purposes, to injure the breed of horses by reason of its defective conformation or physique.

A licence, unless suspended or revoked by the Board, shall remain in force until 31st October following the date of the grant of the licence, but shall be renewed annually subject to the same provisions as apply to the granting of a licence: provided that in the case of a stallion which has attained such age as may be prescribed, and in respect of which a licence has been in force for such number of years as may be prescribed, the renewal of the licence shall not be refused on the ground only of the stallion being affected in its wind.

Provision is made for the transference of a licence if a stallion is sold or let.

A licence or certified copy shall be produced at or before service of a mare, if required by the owner or person in charge of the mare, and at any time if required by an authorised person.

If the Board refuse to grant a licence or revoke or suspend a licence the owner of a stallion may have it examined by a panel of referees appointed by the Board.

The Board has power to make rules in connection with the Act. This Act, subject to certain slight modifications, is also applicable to Ireland.

ANIMALS (TRANSIT AND GENERAL) ORDER OF 1912.

The provisions of this Order relating to vessels and animals carried on vessels shall, except where otherwise stated, apply to any vessel on which animals are carried from a port in Great Britain, or to any such port from a port in Ireland, or the Isle of Man, and to the animals carried on any such vessel.

Protection of Animals.

Provisions as to Vessels carrying Animals.—Animals may not be carried on any hatch above a compartment where other animals are carried, nor in any part of the vessel where in ordinary course of navigation they would interfere with the proper management or ventilation of the vessel or with the efficient working of the boats.

Pens and Fittings.—All animals must be carried in pens, unless they are confined in a suitable crate, box, &c. A crate, box, &c., used for this purpose must be so secured as to prevent its displacement by the motion of the vessel, and must be so placed as to admit a proper supply of fresh air to the animals carried. No pen may exceed 10 feet in length by 9 feet in breadth; the stanchions must be securely fixed to the deck; the material used in construction of the pens must be substantial enough to withstand the action of the weather, and the weight of animals thrown against them. Ship's fittings likely to cause injury or unnecessary suffering to animals must be properly secured and fenced off. The floor of each pen must be fitted with battens or footholds to prevent slipping, and they must be fastened to the deck; the floors must be strewn with sand or other suitable substance. Animals must be protected against injury or unnecessary suffering from undue exposure to the weather.

Passageways.—Every part of the vessel where animals are penned must be provided with one or more passageways leading from the hatchway or entrance to such part of the vessel and giving direct access to each pen. Each passage must have a minimum width of 1 foot and 6 inches, and must be kept free from obstruction. Where sheep are carried on deck, proper gangways or passageways must be provided either between or above the pens in which they are carried.

Ventilation.—All parts of a vessel where animals are carried must be properly ventilated.

Light.—All parts of a vessel over which animals pass, or in which they are

penned, must be properly lighted and arrangements must be made for the provision at all times of adequate light for the proper tending of the animals.

Food and Water.—Animals carried on a voyage that on an average takes more than 18 hours must be supplied with a sufficient amount of suitable food and water. Proper accommodation must be provided on board for the storage of food so that it shall not be unduly exposed to weather.

Securing of Bulls and Fat Cattle.—All bulls and fat horned cattle, and all fat polled cattle carried in the same pens as horned cattle, must be securely tied by the head or neck while on board.

Separation of Mixed Consignments.—Calves, sheep, goats and swine, if carried in the same pen with any head of cattle (other than a calf), or a horse, ass or mule, must be separated therefrom by a suitable partition, but this provision does not apply to the conveyance of a cow with its unweaned calf, if they are separated from other animals.

Attendance.—A sufficient number of qualified attendants must be carried to tend the animals properly.

Shorn Sheep.—Between each first day of November and the next following thirtieth day of April (both days inclusive), shorn sheep may not be carried on deck, except where they were last shorn more than 60 days before being so carried.

Returns as to Casualties.—The owner or charterer of a vessel must keep a record of all animals which have died or have been killed or seriously injured, and all cows which have calved while on board. A monthly return thereof must be made to the B. of A.

Exceptions for Ferry Boats, &c.—The foregoing provisions do not apply to ferry boats and the like, but such vessels must be so fitted as to protect the animals from injury, and the deck must be strewn with sand or other suitable substance.

Approaches, Gangways, &c.—Approaches, gangways and any other apparatus used for the loading or unloading of vessels must be constructed so as not to cause injury or unnecessary suffering.

Overcrowding so as to cause injury or unnecessary suffering to the animals is prohibited.

Injured Animals.—If an animal has a limb broken or is otherwise seriously injured, the master shall cause it to be slaughtered unless he is of the opinion that it can be kept alive and led away without cruelty.

Carriage by Water of Cows in Calf.—No person may ship a cow from any port in Great Britain to a port in the British Isles if it is reasonably probable that she would calve on the vessel or on landing.

Carriage by Water of Unfit Animals.—No person may ship an animal from any port in Great Britain if, owing to infirmity, illness, injury, fatigue or any other cause, it cannot be carried without unnecessary suffering during the intended voyage.

Food and Water during Detention.—An official detaining an animal must cause it to be supplied with food and water during detention, the expenses for the same being recoverable from the owner.

Water at Shipping and Unshipping Places.—At every place where animals are put on board or are landed from vessels, provision must be made for a supply of water for the animals.

Provision to be made at Unshipping Places.—At places where animals are landed provision must be made for their convenient and speedy landing and for a supply of food for them.

Construction of Trucks, &c., used for Carriage of Animals.—No animal may be carried by railway in a truck or other vehicle which is not in accordance with the following provisions, unless the use of such truck or vehicle is authorised by the B. of A.:—Every truck must have spring buffers at each end, and the floor, in order to prevent slipping, shall, in the case of a truck used for the carriage of cattle, be fitted with battens or other proper footholds, and in any other cases either so fitted or be strewn with litter, sand or other suitable substance.

The battens of the truck must be placed across the vehicle except between the doorways, when they must be placed lengthways.

Every truck must be so constructed as to admit of ventilation and inspection at the floor level. Its interior must be free from boltheads, angles, or other projections likely to cause suffering to the animals. Every falling loading door and every gangway, &c., must be fitted with longitudinal battens or other proper footholds. Every truck built after the first day of March, 1904, must be fitted with a roof, and with folding doors of a pattern approved by the B. of A., and all internal projections must be rounded. Every truck or other vehicle must be so constructed as to permit of its being cleansed and disinfected in manner prescribed by this Order.

Securing of Cattle in Railway Trucks.—All bulls, whether polled or not, while being carried in a railway vehicle, must be securely tied by the head or neck. All horned stock carried in the same railway truck with a bull, unless separated therefrom by a suitable partition, must be securely tied by the head or neck.

Carriage by Railway of Cows in Calf.—No cow may be carried on a railway if it is reasonably probable that she may calve during transit.

Carriage by Railway of Unfit Animals.—No animal may be permitted by the owner, or any person in charge, to be carried by railway if, owing to infirmity, illness, injury, fatigue or any other cause, it cannot be carried without unnecessary suffering during the intended transit by railway.

Separation of Mixed Consignments.—Calves, sheep, goats and swine, if carried in the same railway truck with any head of cattle (other than a calf) or a horse, ass or mule, must be separated therefrom by a suitable partition, but this does not apply to a cow and her unweaned calf, if they are separated from other animals.

Overcrowding.—A railway company may not allow overcrowding in any truck so as to cause injury or unnecessary suffering to animals.

Shorn Sheep.—Between the first day of November and the thirtieth day of April following (both days inclusive) every railway truck in which shorn sheep are carried must be covered and enclosed so as to protect the sheep from the weather without obstruction to proper ventilation; but this does not apply to sheep last shorn more than 60 days before being so carried.

Notification by Inspectors of Unfitness of Animals for Conveyance.—If an I.B.A. or an I.L.A. is of opinion that any animal intended to be carried by railway, or on any vessel from Great Britain, is not in a fit condition to travel, or that calving during transit is probable, he may, by serving a notice on the person in charge, prohibit its conveyance. Prohibition extends until the notice is withdrawn.

Cleansing and Disinfection.

Vessels.—A vessel carrying animals by sea, canal, river, &c., must after landing them and before taking on other animals, or other cargo, be cleansed and disinfected as follows:—

All parts of a vessel with which any animal or its droppings have come in contact, must be scraped and swept, then washed with water and then whitewashed or otherwise disinfected as later specified. The application of whitewash is not compulsory for such parts of the vessel as are used for passengers or crew. Fittings, pens, hurdles and utensils used in connection with animals, if not permanently removed from the vessel, are included. Scrapings and sweepings before they are landed must be mixed with quicklime. For vessels, such as ferry boats, making short and frequent journeys, a cleansing and disinfection once in every period of twelve hours within which it is used is sufficient. All head-ropes and halters must be disinfected after they have been used.

Fodder and Litter.—All partly consumed and broken fodder and all litter that has been used for or about animals carried by sea, canal, &c., must, when landed, be mixed with quicklime and removed from contact with animals.

Movable Gangways and other Apparatus.—Movable gangways, cages, &c., used for loading or unloading animals in connection with a vessel or railway truck, &c., must be scraped, swept and washed with water. The scrapings, sweepings, and all dung, litter, &c., removed from such apparatus must be mixed with quicklime and removed from contact with animals.

Trucks, &c.—Railway trucks and vehicles—except a horse-box or guard's van —used for animals on a railway must, on every occasion after an animal is taken out of it, and before any other animal, or fodder, litter or other thing intended to be used for or about animals, is placed in it, be cleansed and disinfected, and the scrapings, sweepings, dung, &c., disposed of as above (vessels).

Horse-Boxes used for Cattle, &c.—A horse-box used for an animal (all ruminating animals and swine) must, after the animal is taken out and before any other is placed therein, be cleansed and disinfected as follows:—The floor of the box and all other parts with which droppings have come in contact must be scraped and swept and all scrapings, sweepings, &c., be removed. The sides of the box must be thoroughly washed. All other parts of the box with which the animal or its droppings have come in contact must be thoroughly washed with water and then be whitewashed or otherwise disinfected as later described. Scrapings, &c., must be mixed with quicklime and be removed.

Vans and Floats used for Diseased or Suspected Animals.—A van or float used for moving animals by road must, on every occasion after a diseased or suspected animal is taken out of it and before any other animal is placed in it, be cleansed and disinfected. Sweepings, &c., must be mixed with quicklime and be removed from contact with animals.

Pens.—Every pen or other place in any way connected with a railway company, for the reception or keeping of animals in connection with their transit by railway, must be cleansed and disinfected either on each day on which it is used or after it has been used, or not later than noon the following day—Sunday excepted. Scrapings, &c., to be treated as before described.

Disease at Place of Landing.—When an animal at a place of landing, or place adjacent thereto, is affected with "disease," that place, or any other place with which the animal has been in contact, must not be used for any other animal liable to contract the disease until such place has been cleansed and disinfected.

Regulations of L.A. as to Cleansing and Disinfection of Lairs.—Empowers the L.A. to make regulations for requiring the occupiers of lairs to cleanse them from time to time, at their own expense, and to disinfect them when required to do so, and for prohibiting the use of lairs for animals, unless the lairs are so paved with cement, or other hard material impervious to water, so as to permit of the same being effectually cleansed by washing. A "Lair" means a building, erection, pen, or other enclosure used for the temporary detention of animals before their exposure for sale.

Miscellaneous.

Cremation of Diseased or Suspected Carcases.—Any carcase required by an Order of the B. of A. to be disposed of by the L.A. may, notwithstanding anything in the Order prescribing the mode of disposal, be destroyed by the L.A. by cremation upon the farm or premises on which the carcase is or upon the nearest available suitable premises. The carcase may not be taken into the district of another L.A. without the consent of the latter.

Digging up of Carcases.—It is unlawful for any person, except with the licence of the B. of A., or permission in writing of an I.B.A., to dig up, or cause to be dug up, the carcase of any "animal" that has been buried.

CHANNEL ISLANDS ANIMALS ORDER, 1896.

Animals brought from the Channel Islands to Great Britain may be landed at any port which is specified by the B. of A. for that purpose without being subject to slaughter or quarantine. The landing of such animals is subject to certain conditions. The vessel in which they were imported must not, within 28 days before taking them on board, have on board any animal exported or carried coastwise from a place in any other country than the United Kingdom, the Channel Islands, or the Isle of Man.

The vessel must not within 21 days of shipping the imported animals, or at any other time since shipping them, have entered any port in any country except the United Kingdom, the Channel Islands, or the Isle of Man.

The imported animals must not have been in contact while on board with any animal exported or carried coastwise from any country except the United Kingdom, the Channel Islands, or the Isle of Man.

Animals when landed are detained in the landing place for twelve hours, and at the end of that period are examined by an I.B.A. in daylight. If found healthy they are to be passed out. If cattle plague or foot-and-mouth disease is found to exist all the animals are to be detained and slaughtered. If any other "contagious disease" exists animals of a similar kind are to be detained and slaughtered, *e.g.*, swine fever and pigs.

ANIMALS (LANDING FROM IRELAND) CONSOLIDATION AND AMENDMENT ORDER, 1914.

Landing Regulations.—Cattle, sheep, goats or swine brought from Ireland may not be landed in Great Britain unless put on board at a port specified in this Order, and they may only be landed at certain specified landing places.

Examination of Animals.—Landed animals are to be isolated and detained until the whole have been examined by a V.I.B.A.

They may not in any case be moved until the expiration of 10 hours after the landing of the last animal. If an animal forming part of the cargo dies or is slaughtered before its examination, the carcase may not be removed from the landing place without the permission of a V.I.B.A.

Movement of Store Sheep.—Sheep may not be moved from a landing place until they have been dipped there, unless such sheep are intended and declared to be for immediate slaughter.

Procedure in Cases of Disease or Calving.—If a V.I.B.A. is of the opinion that an animal in a landing place is affected with or suspected of Cattle Plague (Rinderpest), Pleuro-Pneumonia, Foot-and-Mouth Disease or Sheep Pox, he shall direct the landing place to be closed. In which case—animals may not be landed at, or moved into or out of, the landing place except under licence. Carcases may not be moved without permission. Fodder, dung, hurdles, &c., may not be moved without permission, and before removal must be disinfected. If the disease is sheep-pox, these rules apply to sheep and carcases of sheep only. Persons leaving any such place must wash their hands with soap and water and disinfect their boots and clothes.

A person tending a diseased or suspected animal may not without permission tend any animal not diseased.

Procedure in Case of Sheep-Scab.—Provision is made in the case of sheep-scab being found to exist for the detention and dipping and subsequent movements of diseased and contact sheep, so that the risk of importing sheep-scab into Great Britain is lessened.

Calving Cows.—A cow which has calved during the voyage from Ireland or in a landing place may not be moved from the landing place until permission is granted from an I.B.A. Movement is not permitted until the expiry of 24 hours from the time of calving.

Food and Water.—Animals landed under this Order must be supplied with food and water by the occupier of the landing place until they are taken over by the owners or consignees.

Injured Animals.—If a V.I.B.A. is of the opinion that an animal in a landing place is mortally injured, or so severely injured or so diseased or in such physical condition that it is cruel to keep it alive, he may cause it to be slaughtered.

FOREIGN ANIMALS (QUARANTINE) ORDER, 1896.

Importation of disease into Great Britain is prevented by the prohibition of landing cattle, sheep, goats, and all other ruminating animals and swine from such countries where "disease" exists; by the prohibition of landing of these animals from any country except for immediate slaughter, unless such animals are imported so as to comply with the Quarantine Order.

Conditions of Landing of Foreign Animals subject to Quarantine.

Purposes for which Animals may be Landed.—Foreign animals may be landed at a Foreign Animals Quarantine Station—to be defined by special Order of the Board—if intended for re-shipment to a foreign country, or for purposes of exhibition, or for other exceptional purposes, provided that the proposed landing has been in each case approved by the B. of A. on special application being made.

Animals intended for Re-shipment to a Foreign Country.—The landing at a F.A.Q.S. of a foreign animal intended for re-shipment to a foreign country is subject to the following conditions:—The animal must be accompanied by a declaration of its owner declaring that it is intended for re-shipment to a foreign country, and that to the best of his knowledge it is free from disease. The animal shall not be moved alive out of the station except into a vessel for exportation to a foreign country.

Animals intended for Purposes of Exhibition, or for other Exceptional Purposes (other than re-shipment).—The landing at a F.A.Q.S. of a foreign animal intended as above is subject to these conditions:—The owner to declare the purpose for which it is intended and that to the best of his knowledge it is free from disease. It shall be detained in the station for such period as the B. of A. may direct. When moved therefrom it shall be accompanied with a certificate of health and a movement licence granted by the B. of A.

Movement of Carcases.—No carcase may be moved from a F.A.Q.S. except with the permission of an I.B.A. If an I.B.A. is of opinion that a carcase may introduce disease it may be disposed of as the B. of A. may think fit.

The cleansing and disinfection of landing places, disposal of dung, fodder, &c., and the disinfection of persons and their clothes are provided for in this Order.

FOREIGN ANIMALS ORDER, 1910 AND 1912.

Animals not Intended to be Landed at a Foreign Animals Wharf.

Prohibition of bringing Cattle, Sheep, Goats or Swine from a Scheduled Country into a Port in Great Britain.—Except under licence granted by the B. of A., and subject to the conditions thereby imposed, any cattle, sheep, goats or swine brought from a scheduled country may not be brought into any port in Great Britain. Vessels putting into port under stress of weather, &c., or for any purpose other than the delivery or shipment of cargo, excepted.

Article (1) of the 1912 Amendment Order includes a foreign animal brought from a port in a country which is not a scheduled country, if the animal since it was taken on board at that port has entered a port in a scheduled country.

Conditions Applicable to Vessels while in Port.—In the case of any cattle, sheep, goats or swine brought into a port in Great Britain from a port in a scheduled country, or any animal brought from a foreign country where the vessel has entered a port in a scheduled country since shipping the animals, the following conditions shall apply while the vessel is in port:—The animals may not be moved from the vessel unless under licence from the B. of A., and then only in accordance with the D.A.A. 1894-1909 and this Order. Except where the licence otherwise provides, animals may not be removed until examined by a V.S. appointed by the B. of A. Provision is made for the cleansing and disinfection of persons and things. While the vessel is in port all dung, litter, &c., shall at intervals of not less than 24 hours be mixed with quicklime and disposed of as an I.B.A. may direct.

Article 4 prohibits the landing of animals from certain places and Article 5 prohibits the landing of swine from the United States of America.

Prohibition of Landing of Carcases, &c.—It is not lawful to land in Great Britain a carcase of an animal that has died or been slaughtered on board, if from a scheduled country, or dung, broken fodder, litter, or fittings, pens, hurdles, &c., until these have been cleansed and disinfected, and permission granted by an I.B.A.

Landing of Foreign Animals not brought from a Scheduled Country and destined for a Foreign Animals Wharf in Great Britain.—The landing of foreign animals, except those prohibited from landing, is subject to the following conditions:—That the vessel in which they were imported has not, within 28 days of taking them on board, had on board an animal exported or carried coastwise from a port in a scheduled country. That the vessel has not within 21 days before shipping the animals entered a port in a scheduled country. That the animals have not, while on board, been in contact with an animal exported from a scheduled country.

Disposal of Animals on Landing.—When landed, the animals are to be strictly isolated until examined in daylight by an I.B.A. Slaughter of animals landed at an F.A.W. must take place within 10 days of the landing.

Food and Water must be supplied by the Market Authority to all animals landed until they are taken over by owners or consignees, who must then provide them with a proper and sufficient supply. For sucking calves gruel, milk or other proper food must be supplied.

This Order also provides for the disinfection of fittings, dung, fodder, &c., the disinfection of vessels and parts thereof. Provision is made for the protection of animals and for the fitting of vessels, the regulations being in substance the same as those laid down in the Animals (Transit and General) Order, 1912.

HORSES (IMPORTATION AND TRANSIT) ORDER, 1913.

Importation.

Regulation of Importation of Horses, Asses and Mules.—No horse, ass or mule brought to Great Britain from any other country, except Ireland, the Channel Islands, or the Isle of Man, may be landed in Great Britain unless it is accompanied by a certificate of a V.S. to the effect that he examined the animal on embarkation and found that it did not show symptoms of Glanders (including Farcy), Epizootic Lymphangitis, Ulcerative Lymphangitis, Dourine, Horse-Pox, Sarcoptic Mange, Psoroptic Mange, Influenza, Ringworm or Strangles.

Certain provisions apply to the landing in Great Britain of horses, asses or mules brought from Iceland or the Faroe Islands.

Carriage by Water.

Carriage by Water of Unfit Animals.—See Animals (Transit and General) Order.

Provisions as to Vessels carrying Horses, &c.—The following provisions apply to all vessels on which horses, asses or mules are carried to or from any port in Great Britain.

Fittings of Vessels.—Each horse, ass or mule must be carried in a separate box or stall, except that brood mares, ponies, asses, mules and unbroken horses, and horses in charge of special attendants, may be carried in pens. Boxes, stalls, and pens must be of sufficient size and be substantial enough to withstand the action of weather and the weight of animals thrown against them. A movable box must be so secured as to prevent its displacement by the motion of the vessel. The floor of each box, &c., must be fitted with battens to prevent slipping, and be strewn with sand or other suitable substance.

The vessel must be provided with sufficient and suitable means for slinging the animals carried. The fittings or other parts of the vessel, box, &c., likely to cause injury or suffering to the animals must be fenced off or padded, as the case may require. Horses, &c., must be protected from undue exposure to the weather.

Ventilation and Light.—See Animals (Transit and General) Order.

Passageways.—Every part of the vessel where horses, &c., are carried must be provided with one or more passageways leading from the hatchway or entrance to such part of the vessel, and giving frontal access to each box or stall. Each passageway must have a minimum width of 1 foot and 6 inches, and must be kept free of obstruction.

Food and Water.—Horses, &c., carried on a vessel for a voyage which on an average takes longer than six hours must be provided with food and water while on board. Stowage accommodation must be provided for the food so that it is not damaged by weather. This paragraph does not apply to horses, &c., carried between Great Britain and Ireland, but food and water must be supplied if the owner of the horse should so request before the sailing of the vessel or if the master of the vessel should think it necessary. Suitable accommodation must be provided for the stowage of such food.

Securing of Horses, &c.—All horses, &c., when in a box or stall must, as far as practicable, be securely tied by the head.

Attendance.—A sufficient number of qualified attendants must be carried to tend the animals properly.

Returns as to Casualties.—The owner or charterer of the vessel must keep a record of animals that have died, or have been killed or seriously injured while on board.

Ferry Boats; Approaches, Gangways, &c.; Overcrowding and Injured Animals.—See Animals (Transit and General) Order.

Approved Killing Instruments.—Every vessel on which a horse, &c., is carried must carry a proper killing instrument approved by the B. of A. for the purpose.

Water at Shipping and Unshipping Places.—At every place where horses, &c., are landed or put on board, provision must be made for a supply of water, which is to be given gratuitously.

Provision at Unshipping Places.—Provision must be made for the speedy and convenient landing of the animals and for a supply of food.

Carriage by Railway.—See Animals (Transit and General) Order.

Cleansing and Disinfection.—See Animals (Transit and General) Order; and also :—

Trucks, &c.—A railway truck, if used for horses, asses or mules on a railway, shall, on every occasion after a horse, &c., is taken out of it and before another or any fodder, litter or anything to be used about a horse is put in, must be cleansed and disinfected as follows :—The floor of the truck, and all other parts with which any such animal or its droppings have come in contact shall be scraped and swept and the scrapings and sweepings, and all dung, sawdust, litter, and other matter shall be effectually removed. The same parts of the truck shall be thoroughly washed or scrubbed or scoured with water and then be coated with limewash or as prescribed by the Diseases of Animals (Disinfection) Order of 1906. The scrapings, sweepings, &c., are to be well mixed with quicklime and be removed from contact with horses, asses or mules.

Horse-Boxes, Guards' Vans, &c.—A horse-box or other railway vehicle (not being a truck) if used for horses, asses or mules on a railway shall, after every time it is so used and before being again so used, be cleansed and disinfected as follows :—The floor of the vehicle, and all other parts with which droppings of the animal have come in contact, shall be scraped and swept, and the sweepings, dung, &c., be removed. The sides of the vehicle and all other parts with which the head or any discharge from the mouth or nostrils of the animal has come in contact, and any halter or headstall used for the animal, shall be thoroughly washed with water by means of a brush, sponge or other instrument, and then as far as practicable be disinfected as prescribed (see Disinfection Order, 1906). The scrapings, sweepings, &c., shall be mixed with quicklime and be removed from contact with horses, asses or mules.

General.

Digging up of Carcases.—It shall not be lawful for any person, except with the licence of the Board or permission in writing of an Inspector of the Board, to dig up, or cause to be dug up, the carcase of any horse, ass or mule that has been buried.

EXPORTATION OF HORSES.

Diseases of Animals Act, 1910. Exportation of Horses Order, 1910.

Exportation of Horses Act, 1914.

The Diseases of Animals Act, 1910, amends the Diseases of Animals Acts, 1894 to 1909, in respect of the exportation and shipment of horses. It prohibits the shipment of any horse from any port in Great Britain to any port outside the British Isles, unless immediately before shipment the horse has been examined by a V.I. and has been certified by him to be capable of being conveyed to such port and disembarked without cruelty. The 1914 Act here adds—and to be capable of being worked without suffering. If any horse examined under this Act shall be found by the V.I. to be in such a physical condition that it is cruel to keep it alive (the 1914 Act here adds, or to be permanently incapable of being worked without suffering) the inspector may, without the consent of the owner, cause it to be slaughtered. For the purpose of identification the V.I. may mark horses for which he has given a certificate. If an animal is seriously injured or has a limb broken on a ship the master must cause it to be slaughtered. This Act does not apply to any thoroughbred horse certified by a steward or secretary of the Jockey Club—to have arrived in Great Britain not more than one month before the date of shipment for the purpose of being run in a race; or to be shipped for the purpose of being run in a race; or to be shipped in order to be used for breeding purposes.

The Exportation of Horses Order of 1910 exempts from veterinary examination any horse, ass or mule shipped to any port which is not in Europe; or any horse, ass or mule intended for breeding, racing or exhibition, or of which the Board are satisfied, regard being had to its value and the purpose for which it is exported, that a veterinary examination is unnecessary provided that a permit is obtained for its shipment from the Board. A fee is charged for the examination of horses prior to shipment.

RATS AND MICE (DESTRUCTION) ACT, 1919.

This is an Act to make further provision for the destruction of rats and mice.

Any person who may fail to take necessary and reasonable steps for the destruction of rats and mice on any land of which he is the occupier, or for preventing such land from becoming infested with rats and mice, is liable to a penalty. The Act is to be enforced by local authorities and the port sanitary authorities.

A local authority having power to enforce this Act may give instructions as to the most effective methods that can be adopted for the destruction of rats and mice. If an occupier of any land fails to fulfil the obligations of the Act, the L.A. may serve a notice on him to take the required steps, or, after not less than 24 hours' notice, may take the necessary action themselves and recover expenses from the occupier. The L.A. should, as far as possible, secure collective action for the destruction of the rats and mice. The L.A. may delegate their powers to a committee, and may appoint an officer to act as an inspector to see that the occupiers of land are taking the action required of them.

This Act applies to a vessel as if the vessel were land and the master the occupier. The master may be required to take steps to prevent the escape of rats and mice from his ship.

This Act applies to Scotland and Ireland as well as to England, with some modifications concerning its administration.

FOREIGN HAY AND STRAW ORDER OF 1912, *et seq.*

Prohibits the landing in Great Britain of hay or straw from any country out of the United Kingdom which is not mentioned in a Schedule (the Schedule varies from time to time), with the following exceptions:—Hay or straw which at the time of importation is being used for packing merchandise; or, manufactured straw not intended for use as fodder or litter for animals; or, hay or

straw which is landed at a Foreign Animals Wharf for the purpose of being there destroyed or otherwise disposed of in accordance with any instructions given by the B. of A.; or, hay or straw which is authorised to be landed for use otherwise than as fodder or litter for animals by a licence granted through the B. of A., which licence will contain such conditions as are necessary to prevent the introduction of disease by the hay or straw.

MARKETS AND SALES ORDER OF 1910.

Regulation of Markets and Sales.—Prohibits the holding of any market or sale upon any market-place, sale-yard, highway, or other premises, until after the expiration of 15 days from the date of the previous one, unless the premises, or part thereof sufficient to accommodate the number of animals usually exposed at such a sale, are so paved with cement, concrete, asphalt, or other impervious material, so as to permit of the same being cleansed by washing. This does not apply to the holding of a lawful fair on two or more consecutive days. This order also provides for the cleansing and disinfection of markets and their fittings, &c., after each sale (see Diseases of Animals (Disinfection) Order, 1906).

THE WATER SUPPLY ON RAILWAYS ORDER, 1895.

By this Order the railway companies working the railways specified in the Schedule attached to the Order are required to provide water, to the satisfaction of the B. of A., at each of the stations named in the Schedule for animals carried or about to be carried or having been carried on the railways.

IMPORTATION (RAW TONGUES) ORDER, 1913.

Any box or other receptacle and any packing material in which raw bovine tongues shall be brought to Great Britain from any country out of the United Kingdom which is not mentioned in the Schedule attached to this Order shall, after the tongues have been removed therefrom, forthwith be destroyed by fire by the owner of the tongues at the time of removal, and shall not be permitted to come in contact with any animal.

MINISTRY OF HEALTH ACT, 1919.

This is "An Act to establish a Ministry of Health to exercise in England and Wales powers with respect to Health and Local Government, and confer upon the Chief Secretary certain powers with respect to Health in Ireland and for purposes connected therewith."

It provides for the appointment of a Minister of Health. The duty of the Minister is to take all such steps as may be desirable to secure the preparation, effective carrying out and co-ordination of measures conducive to the health of the people, including measures for the prevention and cure of disease, the avoidance of fraud in connection with alleged remedies therefor, the treatment of physical and mental defects, the treatment and care of the blind, the initiation and direction of research, the collection, preparation, publication, and dissemination of information and statistics relating thereto, and the training of persons for health services.

The Minister of Health takes over all the powers and duties of the Local Government Board, of the Insurance Commissioners and the Welsh Commissioners and all the powers of the Board of Education with respect to attending to the health of expectant mothers and nursing mothers, and of children who have not attained the age of five years and are not in attendance at schools recognised by the Board of Education; all the powers and duties of the Board of Education with respect to the medical inspection and treatment of children and young persons with certain provisions;. all the powers of the Privy Council and of the Lord President of the Council under the Midwives Acts of 1902 and 1918, and such powers of supervising the administration of Part I. of the Children Act, 1908 (which relates to infant life protection), as have before

been exercised by the Secretary of State. The transference of these powers is subject to certain provisos.

The Crown may transfer to the Minister—all or any of the powers and duties of the Minister of Pensions with respect to the health of disabled officers and men after they have left the service; the powers and duties of the Secretary of State under the enactments relating to lunacy and mental deficiency; any other powers and duties in England and Wales of any Government department which appear to the Crown to relate to matters affecting or incidental to the health of the people.

It shall be lawful to establish consultative councils in England and Wales for giving, in accordance with the provisions of the Order, advice and assistance to the Minister in connection with such matters affecting or incidental to the health of the people as may be referred to in such Order. Every such council shall include women as well as men, and shall consist of persons having practical experience of the matters referred to the council.

Provision is made for the appointment by the Minister of officers to constitute a Board of Health for Wales, through whom he may execute and perform his duties and powers; the Board and officers are to act under his directions.

SCOTTISH BOARD OF HEALTH ACT, 1919.

An Act to establish a Scottish Board of Health to exercise powers with respect to Health and Local Government in Scotland, and for purposes connected therewith.

For the purpose of promoting the health of the people throughout Scotland, and for the purpose of the exercise of the powers transferred or conferred by this Act, the Crown appoints a Scottish Board of Health.

The general powers and duties of the Board are to take all such steps as may be desirable to secure the effective carrying out and co-ordination of measures for the prevention and cure of diseases, the initiation and direction of research, the treatment of physical and mental defects, the collection, preparation and publication of information and statistics, and the training of persons for health services.

The constitution of the Board shall be, the Secretary for Scotland to be President, and a Parliamentary Under-Secretary, appointed by the Secretary for Scotland, Vice-President of the Board. The Board, as at first constituted, shall include the existing appointed members of the Local Government Board for Scotland, and such two of the Scottish Insurance Commissioners as the Secretary for Scotland shall nominate, and shall at all times include two registered medical practitioners, one or more women, and a member of the Faculty of Advocates or law agent of not less than ten years' standing. The number of members (other than *ex officio* members) shall at no time exceed six, and, subject as aforesaid, the power of appointing such members shall be exercisable by His Majesty on the recommendation of the Secretary for Scotland.

The following powers and duties are transferred to the Board—all the powers and duties of the Local Government Board of Scotland, of the Scottish Insurance Commissioners, of the Privy Council and of the Lord President of the Council under the Midwife's (Scotland) Act, 1915, of the Secretary for Scotland under the Alkali, &c., Works Regulation Act, 1906, of the Secretary for Scotland under the Burial Grounds (Scotland) Act, 1855, of the Secretary for Scotland under the Rivers Pollution Prevention Acts, 1876 and 1893, section 55 of the Local Government (Scotland) Act, 1889, and the Rivers Pollution Prevention (Border Councils) Act, 1898, of the Secretary for Scotland under the Births, Deaths, and Marriages (Scotland) Acts, 1854 to 1910, the Marriage Notice (Scotland) Act, 1878, and the Vaccination (Scotland) Acts, 1863 to 1907, of the Secretary for Scotland and the Highlands and Islands (Medical Service) Board under the Highlands and Islands (Medical Service) Grant Act, 1913, and all the powers and duties of the Scottish Education Department with respect to the medical inspection and treatment of children and young persons, with certain proviso regarding the last named, and in connection with the National

Insurance (Health) Acts. Provision is made for the transference of other powers.

It shall be lawful to establish consultative councils for giving, in accordance with the provisions of this Order, advice and assistance to the Board in connection with such matters affecting or incidental to the health of the people in Scotland as may be referred to in this Order. Every such council shall include persons of both sexes, and shall consist of persons having practical experience of the matters referred to the council, and due regard shall be had in constituting them to any special interests (including those of local authorities and labour) which may be involved.

PUBLIC HEALTH (SCOTLAND) ACT, 1897.

This is an Act to consolidate and amend the Laws relating to the Public Health in Scotland.

The following excerpts are of interest to the veterinary profession:—

Definitions.—"Board" means the Local Government Board for Scotland. "Medical officer of health" and "medical officer" mean a legally qualified medical practitioner appointed by the local authority under the Burgh Police (Scotland) Act, 1892, or under the Acts repealed by this Act or under this Act. "Sanitary inspector" means a sanitary inspector appointed by the local authority under the Burgh Police Act, &c. "Veterinary surgeon" and "qualified veterinary surgeon" mean a member of the Royal College of Veterinary Surgeons. "Knacker," a person whose business it is to kill any horse, ass, mule or cattle not killed for the purpose of flesh being used as butchers' meat; "knacker's yard," any building or place used for the purpose of such business. "Slaughterer of cattle or horses" means a person whose business it is to kill any description of cattle or horses, asses or mules, for the purpose of the flesh being used as butchers' meat; and the expression "slaughterhouse" means any building or place used for the purpose of such business. An "author of a nuisance" means the person through whose act or default the nuisance is caused, exists, or is continued, whether he be the owner or occupier or both. "Cattle" means bulls, cows, oxen, heifers and calves, and includes sheep, goats and swine. The word "dairy" includes any farm, farmhouse, cowshed, milk store, milk shop or other place from which milk is supplied, or in which milk is kept for the purpose of sale. "Dairyman" includes any cowkeeper, purveyor of milk, or occupier of a dairy. The word "burial" includes cremation. The expressions "day" and "daytime" mean between nine o'clock in the morning and six o'clock in the evening.

Authorities for Execution of Act.—The Local Government Board for Scotland is the central authority.

The Board has power to inquire into the sanitary condition of a district upon written application by a parish council, or ten ratepayers, or upon the report of any of the inspecting officers of the Board.

The Board may, whenever it may seem fitting to them, authorise and empower for a limited time one of the members thereof to conduct any special inquiry in any part of Scotland.

Local Authorities.—The following are the local authorities to execute the Act:—

(*a*) In burghs subject to the provisions of the Burgh Police (Scotland) Act, 1892, the town council or burgh commissioners.

(*b*) In other burghs the town council or board of police.

(*c*) In districts where the county is divided into districts under the Local Government (Scotland) Act, 1889, and, subject to the provisions of section 17 of that Act, as amended by this Act, the district committee.

(*d*) In counties where the county is not so divided, the county council, subject to the provisions of sec. 78, subsec. 3 of the L.G. (S.) A., 1889, as amended by sec. 19, subsec. 7, of the L.G. (S.) A., 1894.

The local authority shall appoint a medical officer, or medical officers, of health and a sanitary inspector, or inspectors, the latter of whom shall be also inspector of common lodging-houses, and the local authority shall, subject to

the approval of the Board, regulate the duties of such medical officers and sanitary inspectors and their relations to each other. . . . The medical officer may, when authorised by the local authority, exercise any of the powers with which the sanitary inspector is invested by this Act.

Sanitary Provisions.

General Nuisances. Definitions.—(*a*) Any premises or part thereof of such a construction or in such a state as to be a nuisance or injurious or dangerous to health.

(*b*) Any street, pool, ditch, gutter, watercourse, sink, cistern, watercloset, earth-closet, privy, urinal, cesspool, drain, dung-pit, or ashpit so foul or in such a state or so situated as to be a nuisance or injurious or dangerous to health.

(*c*) Any well or water supply injurious or dangerous to health.

(*d*) Any stable, byre or other building in which any animal or animals are kept in such a manner or in such numbers as to be a nuisance or injurious or dangerous to health.

(*e*) Any accumulation or deposit, including any deposit of mineral refuse, which is a nuisance or injurious or dangerous to health, or any deposit of offensive matter, refuse or offal or manure (other than farmyard manure or manure from byres or stables, or spent hops from breweries) within 50 yards of any public road wherever situated, or any offensive matter, refuse or offal or manure other than aforesaid contained in uncovered trucks or waggons standing or being at any station or siding or elsewhere on a railway or in canal boats so as to be a nuisance, &c.

(*f*) Any work, manufactory, trade or business, injurious to the health of the neighbourhood or so conducted as to be injurious or dangerous to health, or any collection of rags or bones injurious, &c.

(*g*) Any house or part of a house so overcrowded as to be injurious or dangerous to the health of the inmates.

(*h*) Other definitions of "nuisances" concerning schoolhouses, consumption of smoke from factories, &c., offensive or injurious cemeteries, churchyards, &c.

Every local authority is from time to time to make inspection of their district, with a view to ascertain what nuisances exist and to have them removed.

Offensive Trades.—Any of the following businesses may not be established without the sanction of the local authority:—blood-boiler, bone-boiler, manure manufacturer, soap-boiler, tallow melter, knacker, tanner, tripe-boiler, gut or tripe cleaner, skinner or hide factor, slaughterer of cattle or horses, or any other business which the local authority may declare by order, &c.

A person carrying on the business of a slaughterer of cattle or horses, or knacker, shall not use any premises as a slaughterhouse or knacker's yard without a licence from the local authority; for each offence he shall be liable to a fine not exceeding £5, and the fact that cattle or horses have been taken into unlicensed premises shall be *prima facie* evidence that an offence has been committed.

The local authority of any district other than a burgh may provide, establish, improve or extend and maintain within or without their district, and two or more such authorities may combine, a shambles or slaughterhouse or shambles for the purpose of slaughtering cattle.

The local authority may make by-laws regulating the construction of pigsties, the places in which they are to be erected, and the mode of cleansing them at proper intervals so as to prevent them from becoming a nuisance or dangerous to public health.

Scavenging and Cleansing.—Notice may be given by any local authority for the periodical removal of manure or other refuse matter from mews, stables, or other premises, except cattle courts, in any special scavenging district.

Unsound Food.

Inspection and Destruction of Unsound Meat.—(1) Any medical officer or sanitary inspector, or any veterinary surgeon approved for the purpose of this section by the local authority, may at all reasonable times enter any premises

within the district of the local authority, or search any cart or vehicle, or any barrow, basket, sack, bag or parcel, in order to inspect and examine and may inspect and examine :—

(*a*) Any animal alive or dead intended for the food of man which is exposed for sale, or deposited in any place or is in course of transmission for the purpose of sale, or of preparation for sale; and

(*b*) Any article, whether solid or liquid, intended for the food of man, and sold or exposed for sale, or deposited in any place or in course of transmission for the purpose of sale, or of preparation of sale, the proof that the same was not exposed or deposited or in course of transmission for any such purpose, or was not intended for the food of man, resting with the person charged; and if any such animal or article appears to such medical officer or sanitary inspector or veterinary surgeon to be diseased or unsound or unfit for the food of man, he may seize and carry away the same himself or by an assistant in order to have the same dealt with summarily by a sheriff, magistrate or justice: Provided that in the case of any proceeding under this section with regard to a living animal, the medical officer or sanitary inspector, unless he is himself a qualified veterinary surgeon, shall be accompanied by a veterinary surgeon.

The police force of each police area shall have power to search carts or vehicles or barrows, baskets, sacks, bags, or parcels, and to assist generally in executing and enforcing this section.

(2) If it appears to a sheriff, magistrate or justice that any animal or article which has been seized or is liable to be seized under this section is diseased or unsound or unfit for the food of man, he shall condemn the same, and order it to be destroyed or so disposed of as to prevent it from being exposed for sale or used for the food of man; and the person to whom the same belongs or did belong at the time of sale or exposure for sale or deposit or transmission for the purpose of sale, or of preparation for sale, or in whose possession or on whose premises the same was found, shall be liable to a penalty not exceeding £50 for every animal or article, or if the article consists of fruit, vegetables, corn, bread or flour, for every parcel thereof so condemned, unless he proves that he and the person acting on his behalf (if any) did not know, and could not with reasonable care have known, that it was in such a condition, or, where the proceedings are before a sheriff, at the discretion of the court, if it finds that he has knowingly and wilfully committed the offence, he shall be liable, without the infliction of a penalty, to imprisonment for a term of not more than three months, with or without hard labour, and also to pay all expenses caused by the seizure, detention or disposal thereof: Provided that if such person proves that the animal or part thereof condemned was within a reasonable time prior to the seizure thereof examined upon the premises where the animal was slaughtered and passed by a veterinary surgeon, approved as aforesaid, called in for the purpose, and he shall have granted a certificate of passing as nearly as may be as in the next subsection, he shall be exempt from penalty or imprisonment under this section for such offence.

(3) Each local authority, or two or more local authorities in combination, may, if they think fit, appoint a place or places within its district or their districts, and fix a time or times at which a veterinary surgeon shall attend for the purpose of examining any animal alive or dead which may there be submitted to him, and passing and condemning the same, and such veterinary surgeon shall, on receipt of a fee fixed by the local authority, and paid by the owner, examine and pass or condemn in whole or in part any animal or carcase so submitted to him; and if he shall pass the same he shall grant a certificate stating the name of the owner, date and hour of the examination, and such particulars regarding the animal or carcase as the local authority may prescribe for the purpose of subsequent identification; if he shall condemn the animal or carcase or part thereof, the animal or part condemned shall be retained and be forthwith destroyed by the local authority, or so disposed of as to prevent it from being exposed for sale or used for the food of man, and the owner shall be entitled to the net price realised, from the residual product of the carcase

or part condemned, if any, after deducting the expenses of condemnation and destruction: Provided that no carcase shall be submitted for examination, either under this or the immediately preceding subsection, unless as a whole carcase, including the thoracic and abdominal viscera, in such manner that the examiner shall be readily able to satisfy himself that the organs are those of the carcase under inspection.

(4) Where it is shown that any animal or article liable to be seized under this section and found in the possession of any person was purchased by him or consigned to him from another person for the food of man, and when so purchased or consigned was in such a condition as to be liable to be seized and condemned under this section, the person who so sold or consigned the same shall be liable to be brought to trial in the district in which such animal or article was seized, and on conviction shall be liable to the penalty and imprisonment above mentioned, unless he proves that, at the time he sold or consigned the said animal or article, he and the person acting on his behalf, if any, did not know, and could not with reasonable care have known, that it was in such a condition.

(5) A copy of any certificate granted by a veterinary surgeon under subsections 2 or 3 of this section, shall forthwith be sent by him to the chief constable of the jurisdiction in which the examination of the animal or carcase took place, and the certificate itself shall be sent by the person selling the animal or carcase forthwith after the sale, and not more than 7 days after the date of the certificate, to the chief constable of the jurisdiction in which the sale of the animal or carcase took place, and if any veterinary surgeon or person shall contravene this enactment he shall be liable to a penalty not exceeding £20.

General Prevention and Mitigation of Disease.

Infectious Diseases—Prevention.—No person suffering from an infectious disease, or who is living in an infected house, shall milk any animal, or pick fruit, or shall engage in any occupation connected with food, or carry on any trade or business in such a manner as to be likely to spread such disease, and any person who, knowing himself to be suffering from any infectious disease, contravenes this section, shall be liable to a penalty not exceeding £10.

Inspection of Dairies.—If the medical officer of any district has evidence that any person in the district is suffering from an infectious disease attributable to milk supplied within the district from any dairy situate within the district, or that the milk of any such dairy is likely to cause any such disease to any person residing in the district, such medical officer shall visit the dairy, and the medical officer shall examine the dairy and every person engaged in the service thereof or resident upon the premises or who may be resident in any premises where any person employed in such dairy may reside, and if accompanied by a veterinary surgeon shall examine the animals therein, and the medical officer shall report forthwith the results of his examination accompanied by the report of the veterinary surgeon, if any, to the local authority or any committee appointed to deal with such matters.

If the medical officer of any district has evidence that any person in the district is suffering from any infectious disease attributable to milk from any dairy without the district, or that the milk from any such dairy is likely to cause any such disease to any person residing in the district, such medical officer shall forthwith intimate the same to the local authority of the district in which such dairy is situate, and such other local authority shall be bound, forthwith, by its medical officer to examine the dairy and the persons aforesaid, and by a veterinary surgeon to examine the animals, previous notice of the time of such examination having been given to the local authority of the first-named district, in order that the medical officer or veterinary surgeon may, if they so desire, be present at the examination referred to, and the medical officer of the second-mentioned local authority shall forthwith report the results of his examination, accompanied by the report of the veterinary surgeon, if any, to that local authority appointed to deal with such matters.

The local authority of the district in which the dairy is situated, or any committee appointed for the purpose, shall meet forthwith and consider the reports together with any other evidence that may be submitted by parties

concerned, and shall either make an order requiring the dairyman not to supply any milk from the dairy until the order has been withdrawn by the local authority, or resolve that no such order is necessary.

The local authority may, if the dairy is within the district, require the dairyman not to supply milk either within or without the district, and shall give notice of the fact to the local authority of any district within which they believe milk to be supplied from such dairy.

If a medical officer certifies that an outbreak or spread of infectious disease is attributable to milk supplied by any dairyman, the dairyman must supply information when called upon by the local authority and furnish a list of customers and invoices.

Sewers, Drains and Water Supply.—It shall not be lawful for any person to throw, or suffer to be thrown into any running water, spring, well, lake, pool, reservoir, drain or ditch the carcase of any animal or part thereof, and any person offending against this section shall be liable to a penalty not exceeding £10.

BURGH POLICE (SCOTLAND) ACT, 1892.

This is an Act for regulating the Police and Sanitary Administration of towns and populous places, and for facilitating the union of Police and Municipal Administration in burghs in Scotland.

The following sections are of interest to veterinary practitioners:—

121. All stables and byres, and areas connected therewith, must be constantly kept in a clean condition by the occupier to the satisfaction of the inspector of cleansing or sanitary inspector.

122. It is not lawful to deposit, except for the purpose of removal, any cattle dung upon the streets (mews or stable lanes excepted). No cattle dung, wherever lawfully kept, may be mixed with any dung, soil, dirt, ashes or filth declared by this Act to be the property of the Commissioners of Police.

123. The Commissioners may regulate and limit the time within which all common necessaries and dungsteads shall be emptied and cleaned out.

126. This Act does not prohibit any person from laying dung on any field, nursery or garden ground for manure, but if the M.O.H. certify that the manure so laid is offensive or prejudicial to health, the magistrate may order it to be removed.

278-287. These sections apply to slaughterhouses. Power is given to the Commissioners to provide slaughterhouses for the slaughtering of cattle and also to licence slaughterhouses. Sec. 279 provides that no slaughterhouse may be used or erected without a licence. The M.O.H. has to report on the sanitary condition of licensed slaughterhouses to the Commissioners at least twice every year, and he and other authorised persons may enter slaughterhouses at all reasonable times for the purpose of inspecting them. By-laws must be made for the licensing, registration, regulation, and inspection of slaughterhouses, and preventing cruelty in slaughterhouses, for keeping them clean and for their proper construction. If the Commissioners provide a slaughterhouse no person may slaughter any cattle or beasts, or scald or dress the carcase of any slaughtered cattle within the boundaries of the burgh except an animal is killed for personal or family consumption. Sec. 285 provides for compulsory licensing of slaughterhouses for horses, and prohibits the carrying of the carcases of horses within the burgh unless they are covered up.

DAIRIES, COW-SHEDS, AND MILK-SHOPS ORDER, 1885, *et seq.*

This Order extends to England, Scotland and Wales.

Registration of Dairyman and Others.—Every dairyman, cow-keeper, or purveyor of milk must be registered and each L.A. must keep such a register. A cow-keeper or dairyman who makes butter or cheese and does not purvey milk need not be registered. A person who sells milk of his own cows in small quantities to his own workmen or neighbours need not be registered.

Construction and Water Supply of new Dairies and Cow-Sheds.—A cow-keeper or dairyman may not begin to occupy as a dairy or cow-shed any building

not so occupied at the commencement of this Order, unless he first makes provision, satisfactory to the L.A., for the lighting, ventilation, air-space, cleansing, drainage, and water supply of the building.

Sanitary State of all Dairies and Cow-Sheds.—Whether the building was in occupation at the commencement of this Order or not, the building must be so constructed that it is proper for the health and good condition of the cattle; for the cleanliness of milk vessels used therein for containing milk for sale; and for the protection of the milk against infection and contamination.

Contamination of Milk.—Cow-keepers, dairymen and purveyors of milk are forbidden to allow any person (including himself) suffering from a dangerous infectious disorder, or recently been in contact with such person, to milk cows or in any way to take part in the production, distribution or storage of milk until all danger of infection has ceased.

Proximity of Water-closets, &c.—Water-closets, privies, cesspools, urinals, &c., may not communicate directly with, nor ventilate into, any dairy or room used as a milk-store or milk-shop.

Use of Milk-Store for other Purposes.—A milk-store or milk-shop may not be used as a sleeping compartment or for any other purpose whereby in any manner the milk might become contaminated.

Swine in Cow-Sheds, &c.—Swine may not be kept in any cow-shed or in any place where milk is stored or kept for sale.

Regulations of Local Authority.—A L.A. may make regulations for the inspection of cattle in dairies; for prescribing the lighting, ventilation, cleansing, drainage and water supply of dairies and cow-sheds; for securing the cleanliness of milk-stores, milk-shops and milk vessels; and for prescribing precautions to be taken by purveyors of milk against infection and contamination.

Existence of Disease among Cattle.—If at any time disease exists among cattle in a dairy or cow-shed the milk of the diseased cow—(*a*) may not be mixed with other milk; (*b*) may not be sold or used for human food; (by the Order of 1899 "disease" includes, in the case of a cow, such disease of the udder as shall be certified by a veterinary surgeon to be tubercular); (*c*) such milk may not be sold or used for food of swine, or other animals, unless and until it has been boiled.

Scotland.—Nothing in this Order is to interfere with the operation of the "Cattle-Sheds in Burghs (Scotland) Act, 1866."

Regulations made under this Order are affected by the Milk and Dairies Acts, which see.

MILK AND DAIRIES (SCOTLAND) ACT, 1914.

The object of this Act is *to ensure the Purity of Milk Supplies and to regulate Dairies in Scotland, and for other purposes connected therewith.*

Appointment of Veterinary Inspector and Arrangements for Bacteriological Examinations.—Every L.A. may, and when required by the L.G.B. shall, appoint one or more M.R.C.V.S. to act as V.I., and shall pay to such V.I. a salary approved by the Board. A V.I. so appointed shall not engage in private practice in any district in which he holds office, save with the consent of the Board. Two or more L.As. may, and if required by the Board shall, combine in appointing a V.I. No V.I. so appointed can be removed from office except with sanction of the Board. The L.A. shall, subject to the approval of the Board, regulate the duties, for the purpose of this Act, of the V.I., and his relations to the other officers of the L.A. Where the county council of a county appoint a V.I. under the Diseases of Animals Act or any other Act which they administer, the person so appointed may, and if required by the L.G.B. shall, where the L.A. is a district committee of the county council, be appointed the V.I. under this Act. A L.A. may make arrangements for the bacteriological or other examinations of specimens and samples taken for the purpose of this Act.

Inspection of Dairies.—It shall be the duty of the M.O.H., or S.I. or any other duly authorised officer from time to time, and once at least in every year, to inspect every dairy in the district and to report to the L.A. whether such dairy is in conformity with this Act and its by-laws. It shall be the duty of the

V.I. from time to time, and at least once in every year, to inspect the cattle in every dairy in the district and to report to the L.A. the result of such inspection.

When the M.O.H. or S.I. is of opinion that any milk consigned to the district from any other district is contaminated or impure, or when the M.O.H. has reasonable ground for believing that any milk consigned as aforesaid is likely to cause any infectious disease or other illness, the M.O.H., S.I. or V.I. of the first-named district may inspect the dairy from which the milk has been consigned and to examine the cattle therein, and the dairyman must give facilities for such examination.

Inspection of Premises other than Dairies.—A L.A. may authorise a M.O.H., S.I. or any other officer to inspect from time to time, and to examine the cattle in, any premises from which the occupier sells milk only in small quantities and for their own consumption to persons in his own employment, or to neighbours, notwithstanding that such occupier is not a dairyman within the meaning of this Act, and such person must give facilities for the examination.

Intimation of Inspection of Dairies.—If an official of a L.A. proposes to inspect a dairy in another district, or to examine the cattle there, he must give intimation to the M.O.H. there so that he, the S.I. or the V.I., may be present.

Registration of Dairies.—No person may carry on the trade of dairyman in any premises unless registered by the L.A. A person proposing to carry on the trade of dairyman in any premises must make application for registration not less than a month before beginning to occupy such premises. Before considering the application the L.A. must obtain a report on the premises by their M.O.H., S.I. or other authorised person.

The L.A. must keep a register of dairies and dairymen within their district.

Dairy By-Laws.—The L.A. must make by-laws for their district providing:—

(*a*) For the inspection of cattle in dairies;

(*b*) For prescribing and regulating the structure, lighting, ventilation (including air and floor space), cleansing, drainage, washing and scalding facilities, and water supplies of dairies and their appurtenants;

(*c*) For the prevention of impurities in milk intended for human consumption and for securing the cleanliness and health of the cows and the cleanliness of the persons and clothing of those engaged or assisting in the business, and of the milk, cows, dairies, sculleries, boiler-houses and all utensils, vehicles, and vessels used for the reception, conveyance, storage or sale of milk;

(*d*) For prescribing precautions to be taken by dairymen against infection or contamination.

Any regulations made by the L.A. under the Dairies, Cow-sheds and Milk-shops Orders of 1885, 1887, and 1899 shall continue in force until the date on which by-laws made by the L.A. under this section take effect, but thereafter shall cease to have force or effect.

Regulations by the L.G.B.—The L.G.B., with the concurrence of the Board of Agriculture for Scotland, may from time to time make such general or special orders as they may think fit for carrying this Act into effect, including orders for the following purposes:—

(*a*) Measures to be taken for cooling milk and otherwise protecting milk against infection or contamination.

(*b*) Prohibition of the use of colouring-matter in milk intended for sale for human consumption, and of the addition to milk, other than buttermilk, intended for sale for human consumption, of skimmed or separated milk or water or any other substance, and of the sale for human consumption of milk to which such addition has been made.

(*c*) Prohibition of the word "milk" as the name of any substance not wholly derived from the mammary gland of an animal when such substance is offered for sale, and of the use of the words "butter" or "cheese" as the name of any substance not manufactured from milk so derived when such substance is offered for sale.

(*d*) The manner of conveyance of milk intended for sale for human consumption, including the proper fastening, sealing and identification of churns and vessels used for such conveyance.

(*e*) The regulation of the mixing of the milk in one such churn or vessel with the milk in another.

(*f*) The labelling or distinctive marking of the receptacles of milk for human consumption.

Milk of Diseased Cow.—It is an offence under this Act for any person to consign, sell, offer or expose for sale or keep for sale for human food, or to use or suffer to be used in the manufacture of products for human consumption, the milk of any cow that is suffering from tuberculosis with emaciation, or from tuberculosis of the udder, or from any sore on the teats accompanied by suppuration or bleeding, or from any disease liable to infect or contaminate the milk, or of any cow which is giving tuberculous milk, unless he proves that he did not know and had no reason to suspect that the milk was the milk of such a cow.

Dairyman to Notify Disease.—A dairyman who has any cow which appears to be suffering from any sore on the teats accompanied by suppurating or bleeding, or from any disease liable to infect or contaminate milk, or any cow which to his knowledge is giving tuberculous milk, shall give written notice to the L.A. stating the situation of the dairy.

Notification of Employees suffering from Disease.—If any person resident at or employed in connection with any dairy, or who resides in the same house as any person so employed, shall show symptoms of any infectious disease, the dairyman, on becoming aware thereof, shall report to the M.O.H.

Persons suffering from Disease.—No person may milk cows or handle milk vessels who is suffering from or showing symptoms of any infectious disease, or who is suffering from any suppurating sore or from sore throat or from diarrhœa, unless he has a certificate from a medical practitioner that he may do so without risk of spreading disease. No person may milk cows or handle milk in any way who has been in contact with a person suffering from an infectious disease, or who resides in a house where infectious disease exists.

Procedure for Stoppage of Milk Supplies.—If a M.O.H. has evidence that any person is suffering from an infectious disease or any illness attributable to milk, or that the milk of any dairy in his district is likely to cause such disease or illness, he shall visit the dairy and examine all persons connected with the dairy or with persons serving at the dairy, and he shall if necessary require the V.I. to accompany him and examine the cattle.

If a M.O.H. has evidence that any infectious disease or illness in his district is attributable to milk coming from without his district, he shall notify the M.O.H. concerned, who must then examine the persons in the dairy and the cattle, with the V.I., as above. He must notify the M.O.H. making the complaint as to the time of his intended visit so that the latter and the V.I. can be present if they desire.

Power to Enter and Inspect Dairies, &c.—Within their district the L.A. and any officers appointed by them for the execution of this Act shall have power to enter, inspect and examine at all reasonable times any dairy, and for the purpose of this Act the M.O.H. shall have power to examine any person employed or residing at any dairy, and to require such person to provide him with such specimens of mucus, urine or fæces as he may require for bacteriological examination, and the V.I. shall have power to examine the cattle in any dairy, and every dairyman and the persons in his employment shall give all reasonable facilities and assistance to the L.A. and their officers in the execution of this Act.

Power to take Samples of Milk.—The M.O.H. or S.I. or V.I. may take samples of milk which is sold or exposed or deposited for sale for examination.

Power to apply Tuberculin Test.—A V.I. may apply to any cow in any dairy within the district the tuberculin or other reasonable test for the purpose of discovering whether such cow is suffering from tuberculosis, provided that no such test shall be applied except with the previous consent in writing of the owner of the cow.

Milk Depots.—A L.A. may, subject to the consent of the L.G.B., establish and maintain depots for the sale of milk specially prepared for consumption by infants under two years of age.

Structural Alterations.—This Article gives power to a tenant of a dairy to make any necessary structural alterations in order that his dairy premises may

comply with the requirements of the Act. The authority to carry out alterations is subject to conditions laid down in this Article.

Enactments Repealed by the Operation of this Act.—The whole of the Contagious Diseases (Animals) Act of 1878 as applying to Scotland.

The Contagious Diseases (Animals) Act, 1886, applying to Scotland.

Public Health (Scotland) Act, 1897, Sections 60 and 61.

Burgh Police (Scotland) Act, 1903, Sections 83, 84, 86, 87, 88, 89, 90, 91, 92.

MILK AND DAIRIES (CONSOLIDATION) ACT, 1915.

Power is given to the L.G.B. (see Ministry of Health Act) to make Milk and Dairy Orders for, briefly, the following purposes:—the registration of dairymen and dairies; the inspection of dairy cattle, dairies and persons connected with them; for regulating lighting, ventilation, cleansing, drainage and water supply of dairies; for securing the cleansing of milk-stores and utensils, &c.; for protecting milk against infection or contamination; for preventing danger to health from the sale of infected, contaminated or dirty milk; for regulating the cooling, conveyance and distribution of milk; for labelling, marking and sealing of milk vessels; for prohibiting the addition of colouring matter; for prohibiting or regulating the addition of skimmed or separated milk or water or any other substance to milk intended for human consumption, or the abstraction of butter-fat or any other constituent; and for prohibiting or regulating the sale for human consumption of such milk or milk which has been otherwise artificially treated; for authorising the use of the designation "certified milk" and for generally controlling the sale of certified milk; for authorising a local authority to make regulations for the above purposes, subject to the approval of the L.G.B. (now Ministry of Health).

Milk and Dairy Orders shall be made by the L.G.B. with the concurrence of the Ministry of Agriculture.

MILK AND DAIRIES BILL.

This Bill is designed to secure amendments in the above Act. Its main provisions are—to provide for the licensing of dairymen and dairies, to extend the provisions of the Act in regard to the classification of milk, to make provision for the undertaking by sanitary authorities, with the approval of the Ministry of Health, of the supply and distribution of milk or the cleansing and storage, &c., of milk for sale by dealers, and for the constitution of Milk and Dairies Committees by the local authorities who will administer the Act.

SALE OF FOOD AND DRUGS ACT, 1875.

Mixing Injurious Ingredients with Food.—No person shall mix, colour, stain or powder or permit any other person to mix, colour, stain or powder any article of food with any ingredient or material so as to render the article injurious to health, with intent that the same may be sold in that state, and no person shall sell any such article so mixed, coloured, &c.

Mixing Drugs with Injurious Ingredients.—No person shall, except for the purpose of compounding (as described), mix, colour, stain or powder or permit any other person to mix, &c., any drug with any material so as to affect injuriously the quality or potency of the drug, with intent that the same may be sold in that state, and no person may sell any article so treated. The penalty for the above may be £50 for the first offence.

Sale of Articles of Food and Drugs not of proper Nature, Substance and Quality.—No person shall sell to the prejudice of the purchaser any article of food or any drug which is not of the nature, substance and quality demanded. The penalty may be £20. This does not apply (1) where any matter or ingredient not injurious to health has been added to the food or drug when required for the production or preparation as an article of commerce, in a state fit for carriage or consumption, and not fraudulently to increase the bulk, weight or measure, or to conceal inferior quality; (2) where the food or drug is a proprietary

medicine, or is the subject of a patent, and is supplied in the state required of the patent; (3) where the food or drug is compounded as allowed by the Act; (4) where the food or drug is unavoidably mixed with some extraneous matter in the process of collection or preparation.

Compound Articles of Food and Compounded Drugs.—No person shall sell any compound article of food or compounded drug which is not composed of ingredients in accordance with the demand of the purchaser. Penalty £20.

Protection from Offences by giving Label.—A person may sell a mixed article if he affixes to the article a label to that effect.

Abstraction of Part of an Article of Food before Sale.—No person may abstract from any article of food intended for sale any part of it so as to affect injuriously its quality, substance or nature, or shall sell such without disclosing its nature. Penalty £20.

Other sections of the Act provide for the appointment of analysts, the power to purchase food for the purpose of analysis and for proceedings against offenders, &c.

SALE OF FOOD AND DRUGS ACT, 1899.

This Act amends the previous Act and takes *Precautions against the Importation of Agricultural and other Produce Insufficiently Marked.* Margarine or margarine-cheese must be conspicuously marked as such. Adulterated or impoverished butter, or milk or cream must be so marked. Condensed, separated or skimmed milk must be labelled as such. Any adulterated or impoverished food must be marked with a name or description indicating that the article has been so treated. An importer failing to comply with these requirements is liable to a fine of £20 for the first offence.

An article of food shall be deemed to be adulterated or impoverished if it has been mixed with any other substance, or if any part of it has been abstracted, so as in either case to affect injuriously its quality, substance or nature. An article of food is not considered to be adulterated if there is only added preservative or colouring matter of such a nature and in such quantity as not to render the article injurious to health.

FERTILISERS AND FEEDING STUFFS ACT, 1906.

This is an Act to amend the law with respect to the Sale of Agricultural Fertilisers and Feeding Stuffs.

Persons who sell fertilisers prepared by artificial process in the United Kingdom or imported from abroad must give an invoice stating the name of the article and the respective percentages (if any) of nitrogen, soluble phosphates, insoluble phosphates and potash contained in it; the invoice shall act as a warranty that the percentages in the article shall not differ from those stated beyond the prescribed limits of error.

A person who sells as food for cattle or poultry an article which has been artificially prepared must state on an invoice the name of the article and whether it has been prepared from one substance or seed or more than one substance or seed, and in the case of being artificially prepared, otherwise than being mixed, broken, ground or chopped, what are the respective percentages (if any) of oil and albuminoids; the invoice shall act as a warranty except as regards percentages that these do not differ beyond the prescribed limits of error.

When an article is sold as food for poultry or cattle under a name or description implying that it is prepared from any particular substance or substances, or the product of any particular seed or seeds, and without any indication that it is mixed or compounded with any other substance or seed, there shall be an implied warranty that it is pure and contains only the substances named.

On the sale of any article for use as food for cattle or poultry there shall be implied a warranty that it is suitable for such use.

If a soil fertiliser or food for cattle or poultry is mixed at the request of the purchaser, it is sufficient if the invoice contains a statement of the percentages

with respect to the several ingredients before mixture, and a statement that they have been mixed at the request of the purchaser.

Article 2 provides for the appointment of a chief agricultural analyst by the Board of Agriculture and Fisheries, and of analysts by county councils and county borough councils.

Every purchaser of any article used for fertilising the soil or as food for cattle or poultry who has taken a sample thereof within ten days after delivery of the article or of the invoice, whichever is later, is entitled, on payment of a fee, to have the sample analysed by the agricultural analyst.

An official sampler may take a sample for analysis by the agricultural analyst, with or without the request of the purchaser, of the above-mentioned articles which have been sold or are exposed or kept for sale; the ten days' limit applies in the case of articles that have been sold.

Where a sample has been taken with a view to the institution of any civil or criminal proceedings, the person taking the sample shall divide the sample into three parts, and shall cause each part to be marked, sealed and fastened up, and shall deliver or send by post two parts to the agricultural analyst and one part to the seller.

If the sample has not been divided into parts and sealed, the analyst must send a copy of his certificate to the person who submitted the sample. If it has been divided into parts he is to analyse one of the parts and retain the other and send a certificate of his analysis to the person who submitted the sample, and if this person is not the purchaser also to the latter. In every case a copy of the certificate is to be sent to the seller, or, if his address is not known, then to the purchaser to be forwarded by him. A report of the analysis is also to be sent to the Board of Agriculture and Fisheries.

The Act contains further regulations with regard to legal proceedings, power of the Board of Agriculture and Fisheries to make regulations, provisions as to county and county borough councils, penalties for breach of duty by the seller, &c.

RIVERS POLLUTION PREVENTION ACT, 1876.

This Act provides for the prevention of the pollution of rivers. It deals with four classes of pollution—Solid Matter, Sewage Pollution, Trade Effluents and Mining Effluents.

Prohibition as to putting Solid Matter into Streams.—No solid refuse of any manufactory, manufacturing process or quarry, or any rubbish or cinders, or any other waste or any putrid solid matter may be put into a stream so as to interfere with its due flow or to pollute its waters.

Sewage Pollutions—Prohibition as to Drainage into Streams or Sewers.—No solid or liquid sewage matter may be allowed to flow or fall into a stream unless such flow was practised before 1876, and then the persons responsible must take the best and most practical means to make the sewage harmless.

Manufacturing and Mining Pollutions—Prohibition as to Drainage into Streams from Manufactories.—No poisonous, noxious or polluting liquid proceeding from any factory or manufacturing process may be allowed to fall or flow into a stream. Where such flow existed before the passing of this Act, it may continue if the persons concerned use the best practicable and reasonable available means to render such liquid harmless.

Prohibition as to Drainage from Mines.—No solid matter from mines may pass into a stream in such quantity as to interfere with its due flow, nor any poisonous, noxious or polluting liquid or solid matter proceeding from any mine other than water in the same condition as that in which it has been drained or raised from such mine, unless in the case of poisonous, noxious or polluting matter the persons concerned show that they are using the best practicable and reasonably available means to render harmless such matter.

Definitions.—" Stream " includes the sea to such extent, and tidal waters to such point, as the L.G.B. (Ministry of Health) may determine, and also rivers, streams, canals, lakes and watercourses, other than watercourses at the passing

of this Act mainly used as sewers, and emptying directly into the sea, or tidal waters which have not been determined to be streams. "Solid matter" shall not include particles of matter in suspension in water. "Polluting" shall not include innocuous discoloration.

[Under the diseases (Animals) Act it is unlawful to throw into any river, stream, canal or other water, or into the sea within three miles of the shore, the carcase of any animal which has died of disease. See also Public Health Acts.]

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